Instruments

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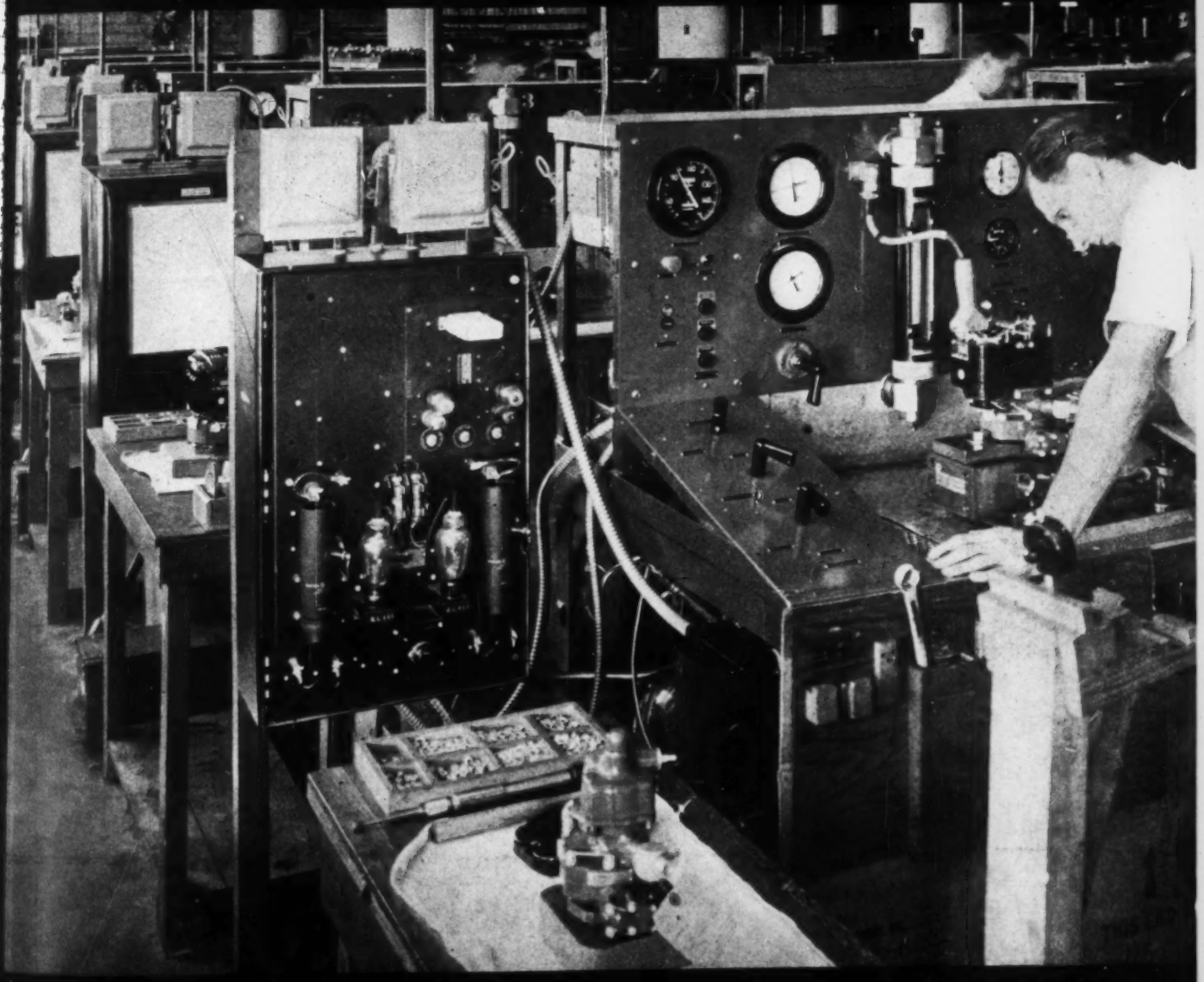
No. 10



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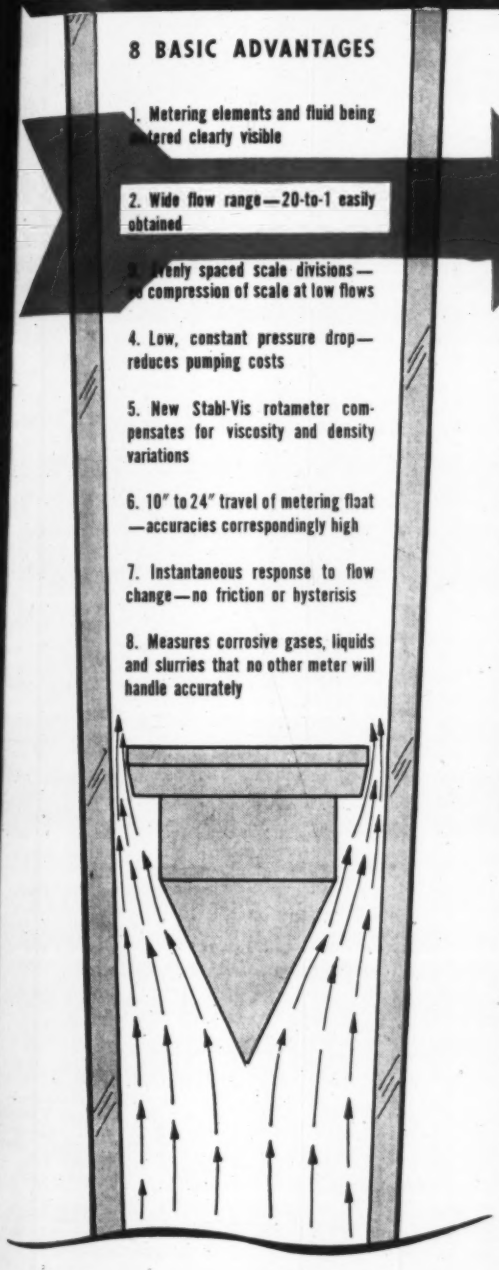
The ROTAMETER

—its basic advantages over head-type meters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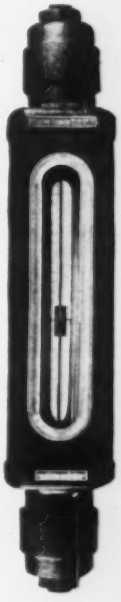

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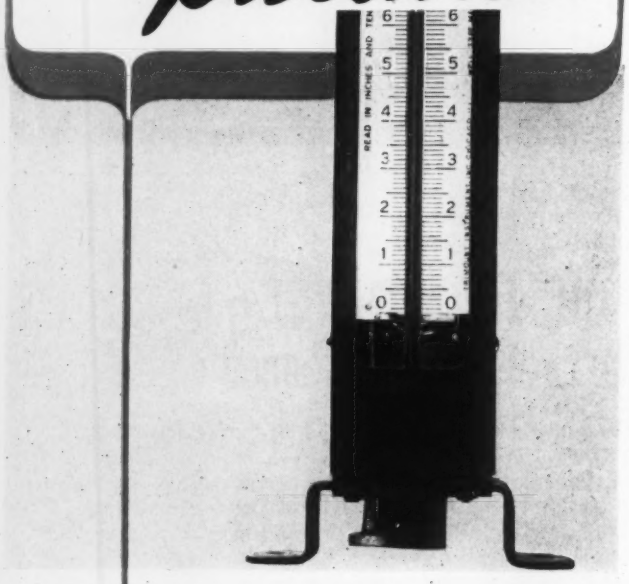

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MANOMETERS

Instruments

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Courtesy General Electric Co., See page 593

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The G-E Press Conference on Industrial Electronics

ON Tuesday, September 14, a "Press Conference on Industrial Electronics" was held by the General Electric Co. at Schenectady. Your editor attended it and this page, consequently, is not so much an editorial as a brief combination of a report and commentary. It has to be brief because a full report (like the "Proceedings" of a scientific or engineering society) would take the shape of a book. It has to be a commentary as well as a report because the attitude of the G-E executives, scientists and engineers who acted as hosts was something like this:

"Of course we've prepared a detailed program, we've set up exhibits, we've arranged group visits timed to the minute, we can load you up with printed and mimeographed matter and with photographs, but never mind all these details and never mind commercial matters: let each one of you fix his attention on the things or trends that will interest his readers; our main purpose is to prove that, industrially speaking, electronics is not a new science nor are its possibilities solely in the future."

The events consisted of (1) *ad lib* visits by early-arriving guests; (2) buffet luncheon; (3) the Conference proper, at which technical papers were presented; (4) an exhibit of industrial electronic equipments; (5) small-group visits to several plant buildings; (6) dinner; (7) brief after-dinner talks; (8) general get-together of hosts and those guests who did not have to catch early-evening trains.

The formal conference was presided over by W. C. Yates, Asst. Mgr., Industrial Division. Six papers were read:

"Industrial Electronics—Not Only a Promise for Tomorrow" By L. A. Umansky, Asst. Mgr., Industrial Engineering Division. 1943 will see 25 billion kilowatt-hours of electrical energy passing through electronic devices. The application of electronics has brought about profound changes in many of our manufacturing industries. "In the true perspective of things, electronics has taken its place as an equal partner, side by side with other electric equipments, ENHANCING RATHER THAN SUPERSEDING THEM."

"Electron Tubes" By W. C. White, Engineer, Electronics Laboratory. Tubes are available that will measure currents of far less than a billionth of an ampere; others will carry thousands of amperes. Voltages of a millionth of a volt can be amplified, and rectification up to 100,000 volts provided for. Tubes are available to provide frequencies up to about a billion cycles. Physically, some tubes fit into a thimble; others are bigger than a man. The present trend in tube development appears to be along the line of stepping up their characteristics over a several-fold range.

"Electronics in Power Conversion and Frequency Changing" By L. W. Morton, Industrial Engineering Division. The application of electronics in the shape of power rectifiers has expedited the recent expansion of facilities for producing light metal. On the subject of frequency conversion, a pioneer d-c. transmission system built by G-E and operated by the N.Y. Power & Light Corp. has been in operation for several years and takes power at 40 cycles and delivers it to another system 17 miles away at 60 cycles.

"Electronic Measurements" By W. C. Hutchins, Manager, Special Products Division. "Progress has many times been stymied because of the need for more sensitive and more accurate measuring equipment. In many cases the solving of these measurement problems appeared to be impossible until electronic equipment was used. . . . It is a fact that during the last ten years the application of electron tubes to measurement problems has enabled the engineer to design and build equipment . . . that otherwise would have been impossible."

"Electronic Heating" By J. P. Jordan, Electronic Heating Section, Industrial Heating Engineering Division. Two broad fields: induction heating of metals and dielectric heating of nonmetallic materials such as plywood, plastics, and foods.

"Industrial Electronic Control" By E. H. Alexander, Engineer, Industrial Control Division. No single industrial electronic equipment has contributed more to war production than resistance welding control. An important recent contribution is the electronic current-regulating compensator. With G-E's electronic motor control drive ("Thy-mo-trol") it is literally possible to make a d-c. motor do useful tricks with power supplied from an a-c. line: operate over a wide speed range and start, accelerate, decelerate, regulate, and reverse, simply by turning a tiny dial or pushing small buttons. [NOTE. The front-cover shows a typical "Thy-motrol" application: driving airplane governor motors from 900 to 3000 r.p.m.—MFB.] Perhaps the best-known electronic control is the photoelectric control, whose applications exceed those of all other industrial electronic devices in quantity and variety.

I have made these abstracts and excerpts extremely brief for two reasons. First, interested readers can obtain copies of some of the papers (perhaps of *any*) by writing to Mr. H. A. Beaudoin, G-E News Bureau, Schenectady, N. Y. The second reason occurred to me after hearing these six papers, while I was looking over the exhibits: the number of G-E electronic instruments and control devices on display seemed to me to be much smaller than the number that have been described in *Instruments*. After getting back to Pittsburgh I had my wife go through the 190 issues since Vol. I No. 1 and make a tabulation. Although she has been my secretary for fourteen years, she could not distinguish between "electronic" and "non-electronic" in many cases. Well, neither could I . . . and neither could anyone, in those cases! Anyway, here is the way I classify (more or less arbitrarily) all G-E items printed in *Instruments:*

Classification	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	**1942**	1943(a)	Total
Purely electronic*	0	0	1	4	2	1	2	0	0	0	0	0	0	1	1	0	12
Partly electronic*	0	0	2	6	5	6	6	9	6	7	4	6	5	7	5	7	81
Non-electronic*	2	3	5	15	11	16	18	19	17	10	17	10	17	14	15	10	199
Total	2	3	8	25	18	23	26	28	23	17	21	16	22	22	21	17	292

*"**Purely** electronic" means electronic tubes, phototubes, cathode-ray tubes etc.; "**partly** electronic" means instruments employing electron tubes; "**non**-electronic" needs no definition but it includes instruments called "electronic" by the manufacturers in spite of the total absence of electronic devices in these instruments.

(a) January-October issues inclusive.

NOTE—Since the early thirties **Instruments** has not made it a point to report new electron tubes as such, because most were new special models for radio, etc., rather than for Instrumentation; and because other technical journals began to make a specialty of reporting all new tubes systematically for their fields.

This analysis, though limited to one manufacturing company, should prove instructive: to post-war planners, for example, because in addition to the twelve G-E electronic instruments we reported in 1942-3, many more were developed but not announced; and this is true of so many companies that, if wartime censorship were suddenly lifted, we might have to put out a big "Now It Can Be Told" supplement on new electronic instruments alone!

Of the plant tour I have many impressions—including the impression that all electronic instrumentation applications I saw had been covered in *Instruments*, but with one notable exception: an electric furnace equipped with a Leeds & Northrup potentiometer recorder-controller commanding G-E "Reactrol" units whereby stepless control is obtained. This new method rates and will get an article.

At the dinner, famous G-E scientists made their appearance and, to the delight of the visiting editors, did not sit at the head table. Naturally, the private conversations cannot be reported but they will result in interesting articles—in *future* issues, needless to add.

My *general* impression? Here it is, from my Oct. 1931 editorial (yes, exactly twelve years ago):

"THE OPEN DOOR"

LITTLE does it matter whether the "lag" of an electron tube is a millionth, a billionth or a trillionth of a second. . . . The most sensitive mechanical, electromagnetic and fluid relays seem extremely sluggish in comparison. . . . Many manufacturers of automatic control instruments have pounced eagerly upon this means. . . . A mere list of successful automatic control applications would cover several pages of fine type.

But let us not be carried away with excessive enthusiasm. . . . Serious problems remain to be solved . . . . To put it in the parlance of Instrumentation, "you can get a wonderful on-and-off action with these gadgets but you can't get an exactly proportional amplification."

There, oh ye physicists in the research departments of instrument-making and -using companies, is a challenge to your ingenuity and resourcefulness! Instrumentation is measurement and control—measurement not only in the sense of "go" and "not go" but in its true sense of assigning exact numerical values. As long ago as 1924 we saw an electric eye sorting cigars into twenty-one grades of color, but the research man who explained it confessed that it was not likely to provide smaller intervals and that it was altogether incapable of providing a *continuous* scale.

Exact measurement requires not only that the instrument be sensitive but that its indications be accurate. Thanks to the electronic engineers we have a degree of sensitivity beyond our wildest dreams. It is up to us to utilize this sensitivity so that the *true value* of whatever is measured will be indicated and recorded and so that the setting point of an automatic controller can be raised or lowered on a numerical—not an arbitrary—scale.

Even at this stage we believe that the General Electric Company is perfectly right in declaring that the name "Thyratron" was applied to one of its series of tubes because it comes from a Greek word which means "door"—because electronic tubes are the open door to marvelous developments.

—M. F. BEHAR

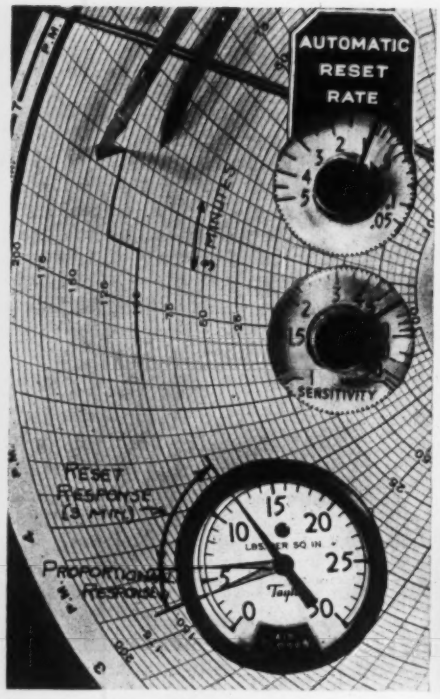

Fig. 17

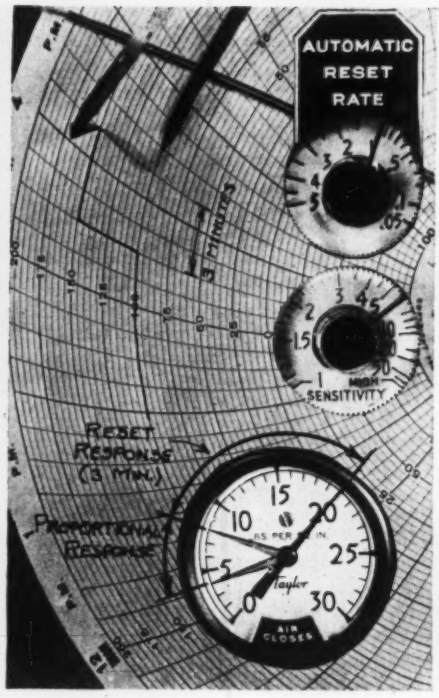

Fig. 18

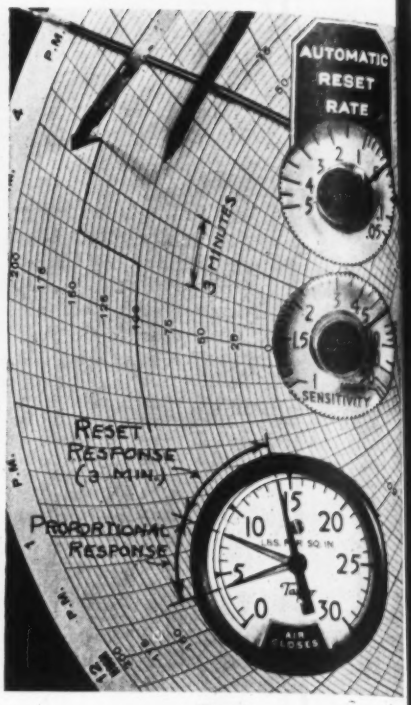

Fig. 19

"On-the-job" Adjustments of Air-operated Recorder-controllers

By J. G. ZIEGLER
Taylor Instrument Companies, Rochester, N. Y.

PART II
"PROPORTIONAL PLUS RESET" CONTROLLERS

IN Part I*, air-operated recorder-controllers giving only the proportional characteristics were considered. It was shown that they are capable of producing stable control when adjusted to the proper proportional sensitivity. They have one major weakness and that is their inability to compensate completely for load changes: allowing a sustained deviation of the controlled temperature for any but the one load for which they are zeroed. When process load changes are large and when the proportional sensitivity is low, the resulting load error may be intolerable.

The second controller characteristic, called AUTOMATIC-RESET, operates to eliminate load error or to minimize it. The proportional characteristic only detects changes in pen position and gives proportional changes in "output" [i.e., in the pressure of the compressed air from the instrument to the controller's valve]; automatic-reset takes into account the distance between the pen and the setting point at any time and gives a *rate* of output pressure *change* proportional to this deviation. If the temperature is too high, automatic-reset *slowly* changes the output pressure in the direction necessary to reduce the temperature. As the temperature approaches the setting point, automatic-reset changes the output pressure even more slowly. When the instrument pen is at the setting point, automatic-reset ceases to act.

The response of a "proportional plus reset" air-operated recorder-controller to a suddenly-applied pen deviation is shown in Fig. 17. In the sensitivity of 6 lbs./in.^{2} per inch, the pen deviation of ⅓" gave an immediate 2-lb. change in output pressure due to the proportional characteristic. After jumping from 4 to 6 lbs. the output pressure continued to rise at a rate of 2 lbs. per minute, reaching 12 lbs. at the end of 3 minutes.

Fig. 18 brings out the fact that the rate is proportional to the deviation: twice as much pen deviation gives twice the rate of output pressure *change*, or 4 lbs./in.^{2} per minute. When pen and setting point coincide, automatic-reset gives a zero rate of change so the output pressure will remain stationary regardless of the actual output pressure.

RESET RATE

A convenient unit to express quantitatively the magnitude of the automatic-reset characteristic is called "RESET RATE," the number of times per minute that the output pressure duplicates the proportional-characteristic change caused by a given pen deviation. In Fig. 17 the output changed 2 lbs./in.^{2} *per minute* for a 2 lbs./in.^{2} proportional-characteristic change. It duplicated the proportional-characteristic change once per minute, so the reset rate is one "per minute." Likewise, in Fig. 18 the reset rate is also one "per minute" since a 4-lb. original change produced a 4-lb. per minute *rate* of change.

Fig. 19 shows the same deviation as in Fig. 18, but the reset rate has been reduced to 0.5 per minute so that the 4-lb. original change gives only 2 lbs./in.^{2} per minute rate of change.

Most "proportional plus reset" control instruments have an adjustment for varying the reset rate. The amount and continuity of adjustment may vary on instruments of different makes but the reset characteristic and the effect of reset rate adjustment is essentially the same on all.

The reset rates necessary on different control applications vary widely: certain temperature control jobs call for reset rates as low as 0.02 per minute while pressure control applications sometimes can use reset rates as high as 50 or 100 per minute.

Determination of the best reset rate adjustment on a job is greatly facilitated if the actual reset rate values obtainable on the instrument are known. Some control instrument dials are calibrated in reset rate; on those calibrated in arbitrary units it is suggested that the actual values be determined for several points on the dial so that a calibration curve can be drawn. If the instrument manufacturer

*Instruments, July 1943, pages 394-397.

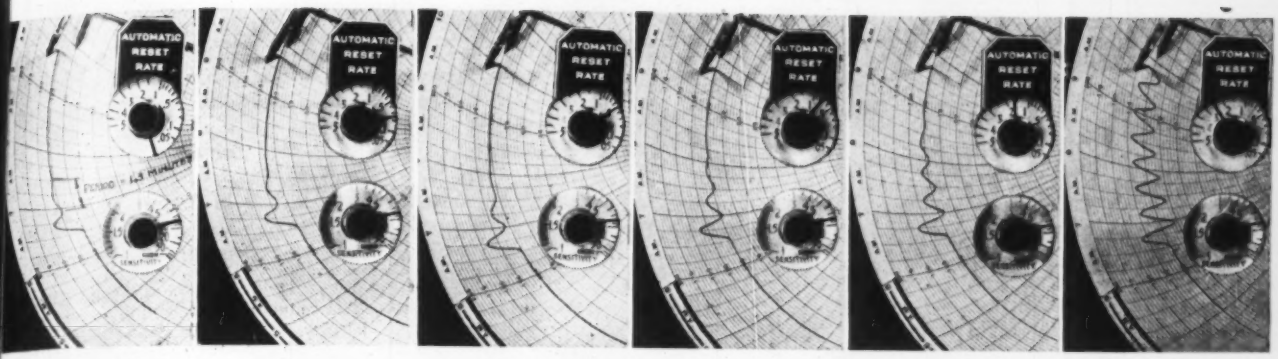

Fig. 20 Fig. 21 Fig. 22 Fig. 23 Fig. 24 Fig. 25

cannot supply the information you can easily make the determination yourself.

To determine reset rates on a recorder-controller instrument:

(1) Fix the pen at some point near the middle of the chart. Adjust the proportional sensitivity to a low value, say 2 or 3 lbs./in.^{2} per inch. Adjust to the fastest reset rate and turn the setting-arm to give an output pressure of say 10 lbs./in.^{2} per inch. You will find that the output pressure will slide one way or another so that you have to move the setting-arm toward the pen in order to maintain 10 lbs./in.^{2}. (It is a good idea to tap the output pressure gage during this procedure so that small rates of change can be detected.) Eventually you will find the setting-arm position which maintains a steady output pressure of 10 lbs./in.^{2}. Wait a few minutes to be sure that the exact zero position is determined. The setting-arm and pen should coincide if the instrument is correctly aligned.

(2) Adjust the reset rate to its minimum and determine the amount of setting-arm movement necessary to give a 1-lb. change on both sides of the zero position. This should be done rather quickly if the minimum reset rate of the particular instrument is not below 0.5 per minute. Mark the two setting-arm positions.

(3) Adjust the reset rate to its maximum and turn the setting-arm to the extreme of the chart which lowers the output pressure. Leave it there for a few minutes and then return the setting-arm to the pen position. If the output pressure is not below 7 lbs./in.^{2}, repeat until it is.

(4) With the pen setting-arm together and the output pressure below 7 lbs., turn the setting-arm to the mark which increases the output pressure 1 lb. The output pressure will jump up 1 lb. and continue upward slowly. When the output pressure crosses 8 lbs. (you are tapping the gage now) start timing and at the end of one minute note the new output pressure. *The pressure change during this minute is numerically equal to the reset rate.* For example, if the output pressure changed from 8 to 10 lbs. during this one-minute period, the reset rate would be 2 per minute.

(5) Move the setting-arm to the mark on the other side of the pen and check the reset rate as the output pressure descends. The two values should check quite closely.

On "very fast" reset rates, the output pressure may go to one extreme before the one-minute period. If so, simply check the rate for a shorter time. For example, if the output pressure changed from 8 to 12 lbs. in 15 seconds, it varied at a rate of 16 lbs. per minute, so the reset rate is 16 per minute.

Determination of low reset rates can be done more quickly if greater driving forces are applied. Find the setting-arm position required to give say a 6-lb. change due to the proportional characteristic (instead of the 1-lb. change prescribed above) and clock the rate of change which results. If, for this setting-arm position, the output pressure changes 3 lbs. in 5 minutes, the reset rate would be 3 lbs. per 5 minutes per 6-lb. driving force or—

$$\frac{3}{(5)\,(6)} = 0.1 \text{ per minute}$$

ADJUSTING FOR STABILITY

As we have seen, the automatic-reset characteristic is useful for eliminating load error; it is not a stabilizing characteristic as is commonly thought; instead *it decreases the stability of control.* On a given job, an increase in reset rate causes an increase in amplitude ratio.* This decreased stability can be overcome by decreasing the proportional sensitivity but if we progressively increase reset rate and cut down sensitivity to maintain the same amplitude ratio we would find that the control became poorer and poorer. The period of oscillation would progressively increase and, for a given load change, the initial deviation would increase. So we might say that the automatic-reset characteristic is a "necessary evil" because the only good thing it does is eliminate load error; in all other respects it is bad.

Adjustment of the reset rate on a job must be a compromise: fast enough to give a reasonably rapid return to the setting point but not so fast that excessive lowering of sensitivity is necessary in order to maintain stability. Look now at the recovery curve of Fig. 23. This is the same process that drew the previous curves in Part I with the same load change applied. This curve, obtained at a sensitivity of 8 and a reset rate of 0.75 per minute, represents about the optimum that can be obtained with this type of controller. The lower reset rates of 0.5 and 0.25, used in Figs. 22 and 21, give excessively slow return to the setting point. A reset rate of zero in Fig. 20 shows no tendency of the pen to return.

To the right of Fig. 23, increased reset rates quickly reduce the stability as shown in Figs. 24 and 25. So the setting of 0.75 per minute gives about the best recovery curve, that shown in Fig. 23.

RELATION BETWEEN RESET RATE AND PERIOD OF OSCILLATION

Tests on a large number of control applications indicate that a handy relationship seems to exist between reset rate and period of oscillation. On pressure control jobs with short periods, fast reset rates can be used; long-period applications require slow reset rates. In fact, the best reset rate seems to be about equal to *the reciprocal of the period of oscillation.* A job having a 10-minute period would use a reset rate of 0.1 per minute; a job with a ½ minute period, a reset rate of 2 per minute. A clock which rotated the chart in one hour was used to draw the curves for these articles. The actual period of oscillation in Fig. 20 is 1.3 minutes. The reciprocal of this, 1/1.3, is 0.75 per minute, the reset rate used in Fig. 23. This provides an easy method for finding the approximate reset rate required on a job.

The period of oscillation should be determined with the reset rate adjusted to the lowest value possible on the particular controller and with the sensitivity adjustment that gives a damped oscillation with an amplitude ratio below 1.0 and above 0.2 but preferably around 0.25. The reset rate is then increased to the value calculated from the period (or the nearest adjustment below the correct value if the adjustment is in steps) and the sensitivity lowered until an amplitude ratio of 0.25 to 0.35 is obtained.

EXAMPLE OF ON-THE-JOB ADJUSTMENT

Let us go through the adjustment of a "proportional-plus-reset" controller on a job. We will assume that the process is under manual control and that large disturbances are to

*The amplitude of one swing of the pen, divided by the amplitude of the preceding swing in the same direction.

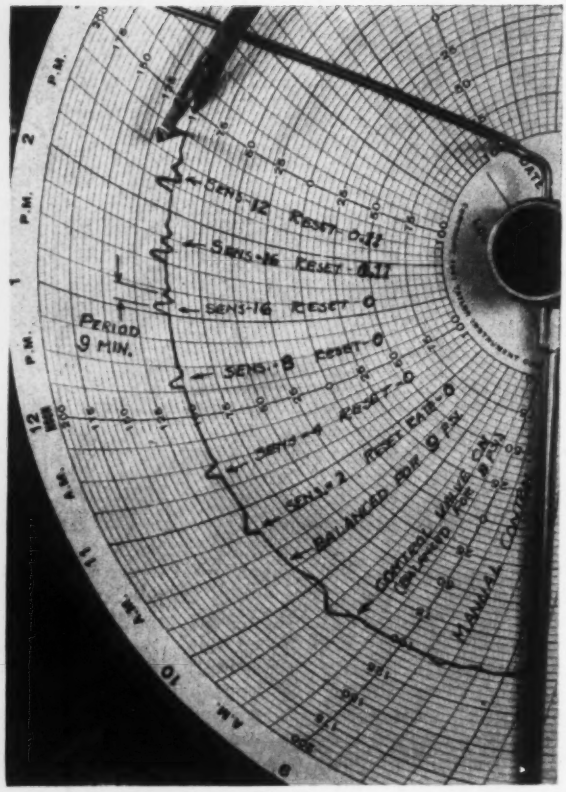

Fig. 26

be avoided when the controller is cut on and during its adjustment.

The FIRST STEP, as in the adjustment of a proportional-characteristic controller, is to estimate the output pressure required to give the necessary control valve opening. The better the guess, the less disturbance will be caused when the controller is cut on. Say that 8 lbs. output pressure is a reasonable guess on the process for which an adjustment chart is shown in Fig. 26.

The SECOND STEP is to get the controller balanced for this 8-lb. output pressure. This was done while the process was still on manual control around 9:15. There are two ways to balance or zero a "proportional-plus-reset" controller:

A. If the controller has its own air supply reducing valve, turn the instrument setting-arm as far as possible in the direction which increases the output pressure. Adjust the sensitivity to a low value of 2 or 3 lbs./in.^{2} per inch and adjust the reset rate to its maximum value. Adjust the controller air supply down until the output pressure comes to the required value; in our example, 8 lbs./in.^{2}. Then wait a sufficient length of time for the automatic reset mechanism to balance. The time will depend upon the maximum reset rate available in the controller: if the maximum is 1 per minute, it will take about five minutes; if the maximum is 5 per minute or more, the balancing will be essentially complete in 1 minute. Check by moving the setting-arm past the pen position. When balance is achieved, the output pressure should start to fall just as the setting-arm passes the pen. As soon as this occurs, adjust the reset rate down to its minimum value.

B. If the instrument does not have its own air supply reducing valve, adjust the sensitivity to 2 or 3 lbs./in.^{2} per inch and the reset rate as fast as possible. Turn the setting-arm until the output pressure comes to the desired value (8 lbs. in this case). If pen and setting-arm are not together, the output pressure will not stay at the right value but will slide one way or the other. As this occurs, move the setting-arm toward the pen to maintain the same pressure. (Tap the output gage during this maneuver.) You will find as the setting-arm comes nearer the pen, slower and slower movement is required until eventually they almost coincide and the output pressure remains stationary. When this point is reached, adjust the reset rate to its minimum.

The THIRD STEP is to open the steam (or other heating medium) to the control valve and close the by-pass valve; if the required output pressure was correctly estimated, the pen will not move. In Fig. 26 this was done at 9:30, but the pen started up, indicating that the 8-lb. guess was not correct. The error is corrected in one of two ways depending on the method used in step 2:

A. The setting-arm is left at the extreme of the chart as in step 2 and the output pressure increased or decreased by means of the steam supply reducing valve in order to bring the pen back to the desired point. The reducing valve simply serves to remotely position the control valve. When the pen has settled at the correct value, wait a minute or so for the pressure to equalize at the new value. Then cut the reset rate to a minimum, bring the setting-arm behind the pen and adjust the air supply pressure back up to the normal value. The instrument output pressure should not change appreciably. The controller is now controlling the process but with excessively low sensitivity and reset rate settings.

B. When the pen begins to deviate, move the setting-arm in the opposite direction enough to return the pen to the correct value. In this case you use the setting-arm to manually position the control valve since the effect of pen movement on the output pressure will be slight in the low sensitivity of 2 or 3 lbs./in.^{2} per inch. Note the new output pressure. (On Fig. 26 the required output pressure was about 9 lbs./in.^{2} so the guess of 8 lbs. was not too bad.) Increase the reset rate to 3 or 4 per minute if possible and start moving the setting-arm toward the pen to hold the output pressure at the same value. Tap the gage and *watch the gage*, not the setting-arm or pen. You will have to move the setting-arm fast at first and then more slowly as the setting-arm approaches the pen. When the output seems to be stationary, look up at the chart and you will find that the setting-arm is behind the pen. Quickly adjust the reset rate back to minimum.

The FOURTH STEP is to find the period of oscillation. To do this the sensitivity must be increased until a damped oscillation is produced as was done with the proportional-characteristic instrument in Part I. In fact, with the completion of step three, we have essentially a proportional-control instrument since the reset rate is zero or very low. In step three the instrument was zeroed for the required output.

In Fig. 26, the controller was on the line and zeroed for 9 lbs./in.^{2} output pressure at 10:30 A.M. The sensitivity was at 2 lbs./in.^{2} per inch and the reset rate at zero. A disturbance was made by moving the setting-arm away from the pen for a few moments to start an oscillation. The excessive stability indicated that an increased sensitivity was required so it was increased to 4, to 8, and to 16 lbs./in.^{2} per inch, and disturbances created. At 16, a good definite damped oscillation with an amplitude ratio of about 0.3 resulted. The period of oscillation was approximately 9 minutes.

STEP FIVE is the calculation and adjustment of the reset rate. The calculation involved only taking the reciprocal of the period of 9 minutes, indicating that a reset rate of 1/9th or 0.11 per minute is required. The particular controller used in Fig. 26 had a continuous adjustment so the reset rate was set at this value. If a controller with stepwise adjustment had been used, the adjustment giving the nearest *lower* reset rate would be used. For example: The reset rates available might be 0.02, 0.04, 0.08, 0.15 and 0.25, in which case the rate should be adjusted for 0.08 because it is the nearest value below 0.11 per minute.

SIXTH AND LAST STEP is to find the sensitivity which gives the correct stability. On Fig. 26, a check was made at 1:30 with the sensitivity still at 16. As expected, the addition of automatic reset increased the amplitude ratio. The sensitivity was then decreased to 12 and another disturbance created which showed a good amplitude ratio of about 0.25, so no further adjustment was made.

In Part I it was pointed out that at different load conditions, initially-determined sensitivity settings might have to be modified. This is also true on the "proportional plus reset" controller with the additional nuisance that the reset rate may also be too high and cause trouble at other loads. If less stable control develops after the initial adjustment, don't turn knobs at random because you don't know whether the sensitivity or reset rate is the trouble-maker. Check methodically: cut the reset rate to a minimum and redetermine the period of oscillation. If it has not changed, the trouble came from the proportional characteristic so put in reset

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A "Refresher" on Vibratory Motion for Instrument Men

By S. R. WILLIAMS
Professor of Physics, Amherst College, Amherst, Mass.

Thus far we have looked into various types of continuous motion. Now we come to another kind called vibratory motion, motion which repeats itself in a to and fro movement, either in a translatory or in a rotatory fashion. All time-measuring devices make use of this type of motion—even to the synchronous electric motor clocks which so many of us have in our homes and offices.

In the vibratory types of motion we should differentiate clearly between those which execute their movements as simple harmonic motion (SHM) and those which do not. All simple harmonic motion is vibratory, but not all vibratory motion is simple harmonic motion.

Demonstration to Show the Difference Between SHM and Vibratory Motion Which is Not SHM

Fig. 1 shows a mechanism with four different cams on a common shaft which can be rotated by hand. As these cams rotate with the shaft they cause the horizontal rods, 1, 2, 3, and 4, to move back and forth with as many kinds of vibratory motions as there are cams, but only one is even approximately simple harmonic motion. The shorter the stroke the more nearly does No. 4 approach SHM. It is the same type of motion as is found in the piston of a steam engine.

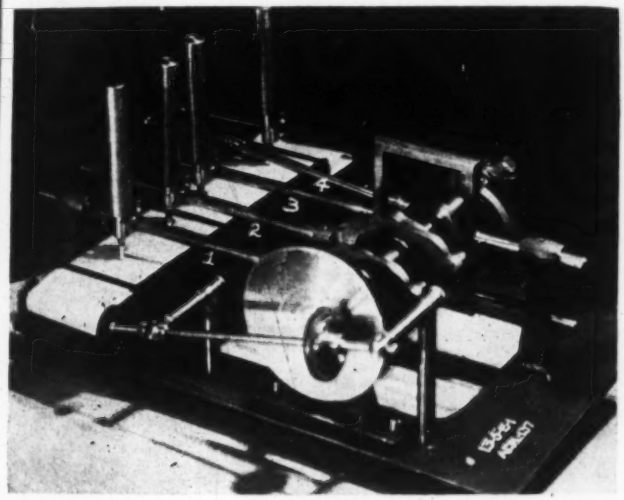

Fig. 1. Apparatus to show the difference between vibratory motion which is simple harmonic motion and that which is not.

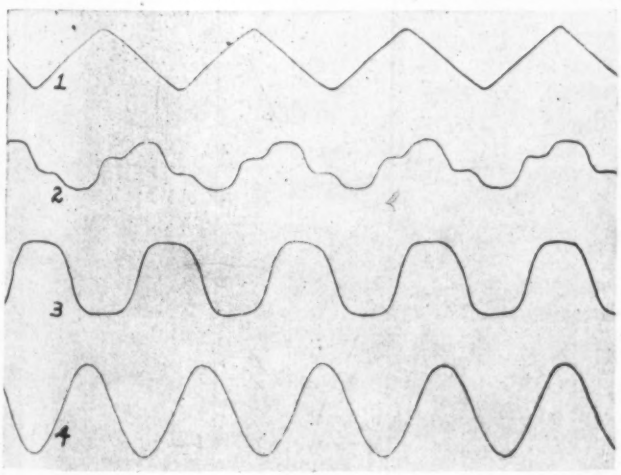

Fig. 2. Curves drawn by the machine shown in Fig. 1. Curves 1, 2 and 3 are periodic but not simple harmonic curves. Curve 4 is approximately SHM.

By attaching a pencil or pen to the horizontal rods as they vibrate back and forth, the pencil or pen can be made to mark a line on a strip of paper placed under the point. If, as the pen moves back and forth with uniform speed of rotation of the shaft carrying the cams, the paper is made to move with the uniform motion at right angles to the movement of the pen point, the pen will record the displacement of its point from the central position as time progresses. The curve thus obtained is a record of displacement against time. Fig. 2 shows the four records for the four vibratory motions. If the record is a curve to which the equation, Displacement $= r \sin \phi$, applies, then we know the movement is one of SHM.

For the other curves to which $D = r \sin \phi$ is not applicable, we simply say that the motion is vibratory or periodic. The four records show at once which ones are merely vibratory motions, and which one is approximately SHM. No. 4 is the latter.

Designers and users of instruments of measurement and control would do well to keep in mind that a cam can be designed to give any type of vibratory motion needed or desired in such instruments. There is a cam or eccentric for every type of periodic motion desired.

Demonstration of Simple Harmonic Motion of Translation

Fig. 3 shows a kilogram mass, M, attached to the lower end of a spiral spring, S, such as one finds in the end of a

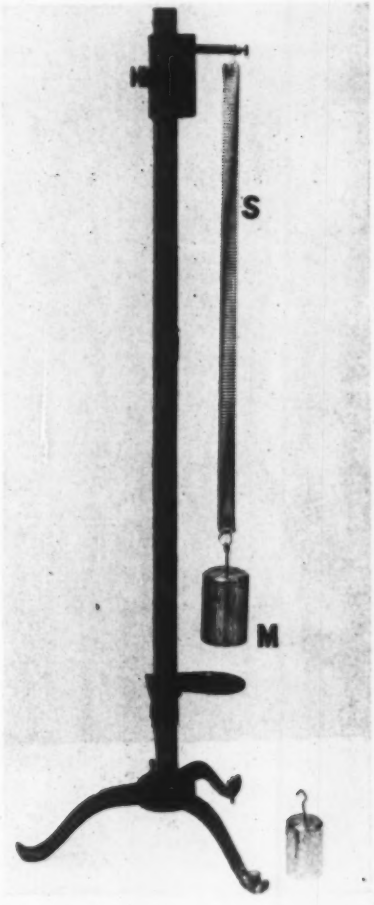

Fig 3. Illustrating simple harmonic motion of translation, i.e., motion in a straight line.

window shade roller. The mass stretches the spring to a certain point of rest which we will call the starting point or position of equilibrium. If the mass is now pulled a bit farther down and then released, the mass will begin to vibrate back and forth with SHM in a straight line. The amplitude of the vibration is the distance from the position of rest to the extreme position taken by the mass, i.e., the maximum displacement. The practical physicist is interested more particularly in SHM because it fits in better with many of the motions which he studies in sound, electricity, and light. The complete or full period of vibration, T, is the time which elapses between the instant the mass is in one position and the instant it is in the same position going in the same direction again.

Gradually, the amplitude of vibration of the mass in Fig. 3 dies down and this motion will demonstrate damped vibratory motion. Fig. 4 shows how an electrical oscillation dies down or "tails out" as in the discharge of a Leyden jar. Over short intervals of time, however, we may consider the motion as SHM. Some clocks have vibrators in them which move up and down as does the mass in Fig. 3. From the energy stored in the spring of the clock (the mainspring), these vibrations may be maintained indefinitely. It is in this form of vibration that we have real simple harmonic motion.

Fig. 5 shows a clock with its pendulum, and beside it is a Kater's compound pendulum. In the energy of the spring in the clock the full amplitude of the vibrations of the pendulum is maintained, and the motion of the pendulum bob is discussed as simple harmonic motion. Over short intervals of time we treat the compound pendulum as a case of simple harmonic motion, although we know its amplitude is slowly decreasing.

Demonstration of SHM of Rotation

The simple harmonic motion of rotatory motion is illustrated by the balance wheel of a watch or alarm clock. (See Fig. 6.) By reason of the energy of the wound mainspring of the watch, the SHM of the balance wheel is kept up continuously. Fig. 7 shows a model of a balance wheel with its hairspring, S. This outfit over a short length of time may be considered as SHM of rotation. By means of a string wrapped around the axis of rotation and carried back over the pulley, P, the mass, M, can be made to move

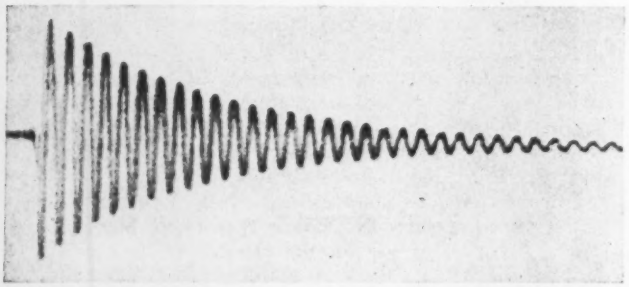

Fig. 4. When a simple periodic motion begins to have its amplitude of vibration decrease as shown in this figure, the motion is called "damped vibratory motion."

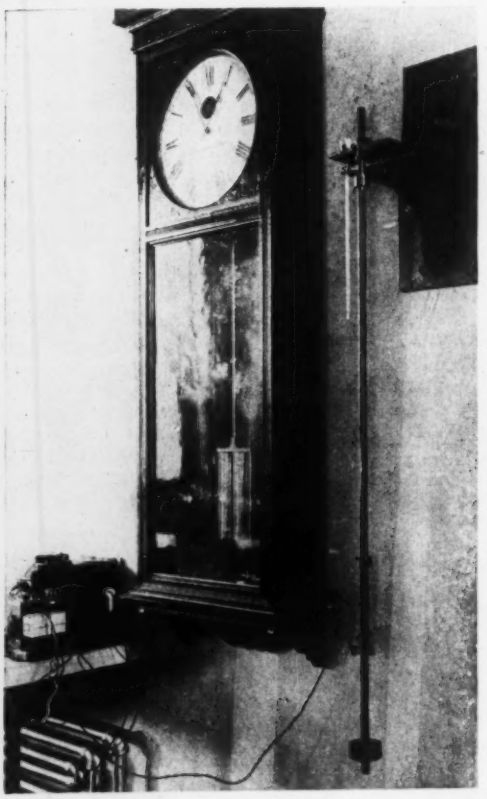

Fig. 5. Standard Pendulum Clock with Kater's Pendulum beside it. The Standard is for timing the period of the compound pendulum.

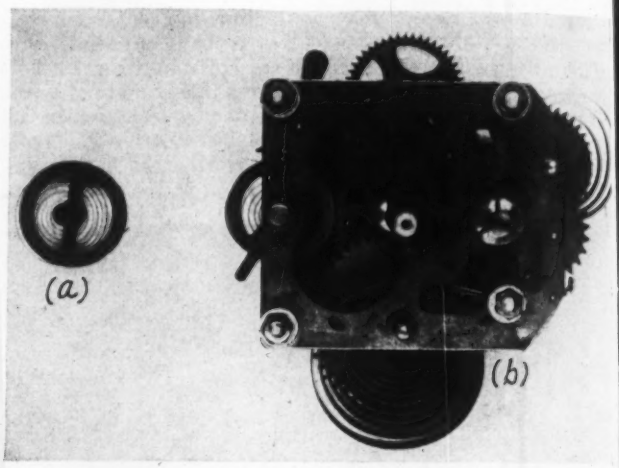

Fig. 6. Balance wheel and hair spring to a clock. (*a*) Unattached. (*b*) In the works of a clock.

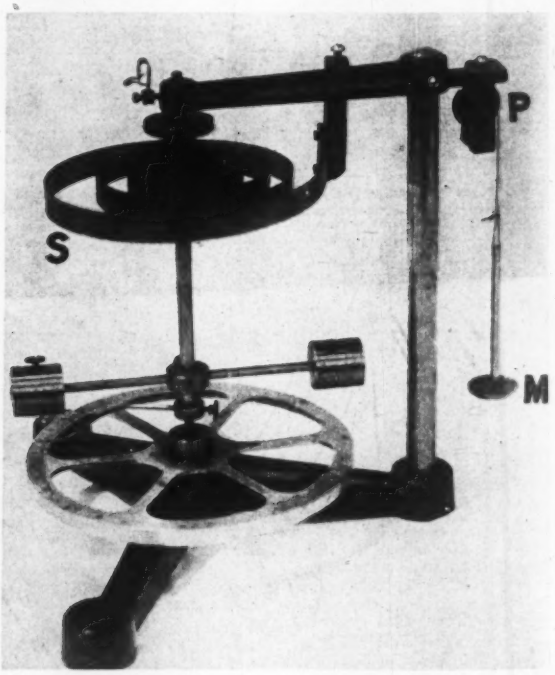

Fig. 7. Model of a watch or clock balance wheel with variable moment of inertia. Illustrates simple harmonic motion of rotation.

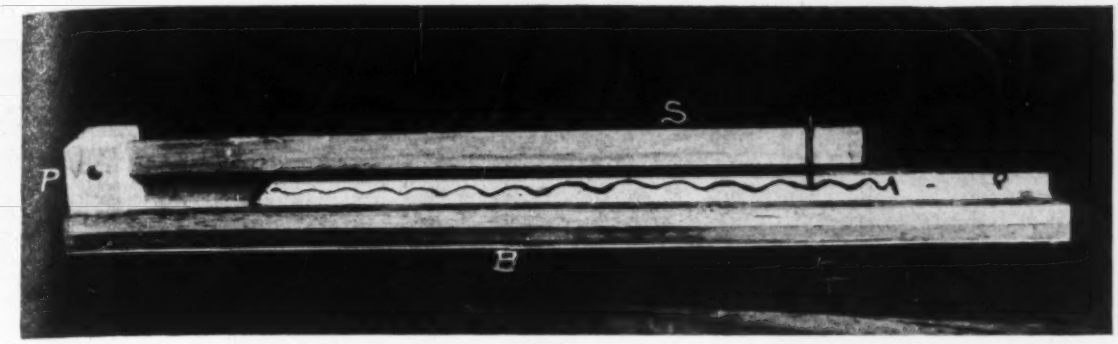

Fig. 8. A slat clamped rigidly at one end has its free end vibrating back and forth. The free end carries a small camel's hair brush which records its movement on the sheet of paper moved lengthwise of the instrument.

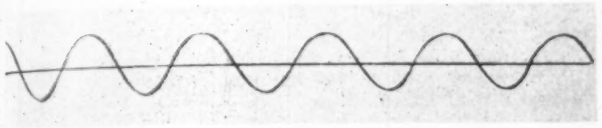

Fig. 9. Harmonic curve drawn by the brush on the instrument shown in Fig. 8.

up and down linearly (SHM of translation) at the same time the main system is executing SHM of rotation.

In the demonstration, shown by Fig. 1, a curve was drawn by moving a strip of paper under the point of the pen attached to the rod moving back and forth periodically. It was a curve to show the displacements of the vibratory motion as time progressed. This may be shown in a very simple way by the following.

Demonstration of a Harmonic Curve

A harmonic curve is drawn by a device such as shown in Fig. 8. A long slat, S, about the dimensions of an ordinary lath, say 0.75 centimeter thick and 2.5 centimeters broad and 80 centimeters long, is tightly clamped at one end in a substantial wooden post, P, attached rigidly to a board, B, 15 centimeters wide and about 175 centimeters long. The height of the lower edge of the slat above the top surface of the wooden base is about 3.5 centimeters. Attached to the free end of the slat is a small, round camel's hair brush, usually made up with a quill as a handle. This can be easily attached by a rubber band. On top of the wooden base but sliding between guide rails is a thin strip of wood about 13 centimeters wide and 1 centimeter thick, with a length of say 60 centimeters. The end of the slat carrying the camel's hair brush is pulled to one side and released, whereupon it executes a vibratory motion back and forth across the movable board.

On top of the movable strip of thin board, there is fastened by thumbtacks a strip of paper the width of the movable strip of wood. If, while the camel's hair brush dipped in black ink is moving back and forth, the strip of paper under it is moved longitudinally, the brush will draw a harmonic curve which will represent its displacement at any instant from its position of equilibrium. This curve may be seen in Fig. 9.

The movement of the mass, M, in Fig. 3 is called SHM. How does it differ from periodic motion which is not SHM? Somebody discovered that when a body moves around a circle with uniform speed, the projection of the uniform circular motion on the diameter of the circle is just like the motion of M in Fig. 3; and so simple harmonic motion is defined as the projection of uniform circular motion upon the diameter of the circle in which the motion takes place.

Demonstration of SHM and Projection of Uniform Circular Motion as Being the Same

In Fig. 10 a circular disk, D, is turned with uniform speed by a hand crank on the rear of the disk. As the disk turns, the pin, P_1, moves in a circle with uniform speed. At the same time the frame, F, is carried along with it because P_1 is thrust up through a close-fitting slot in the

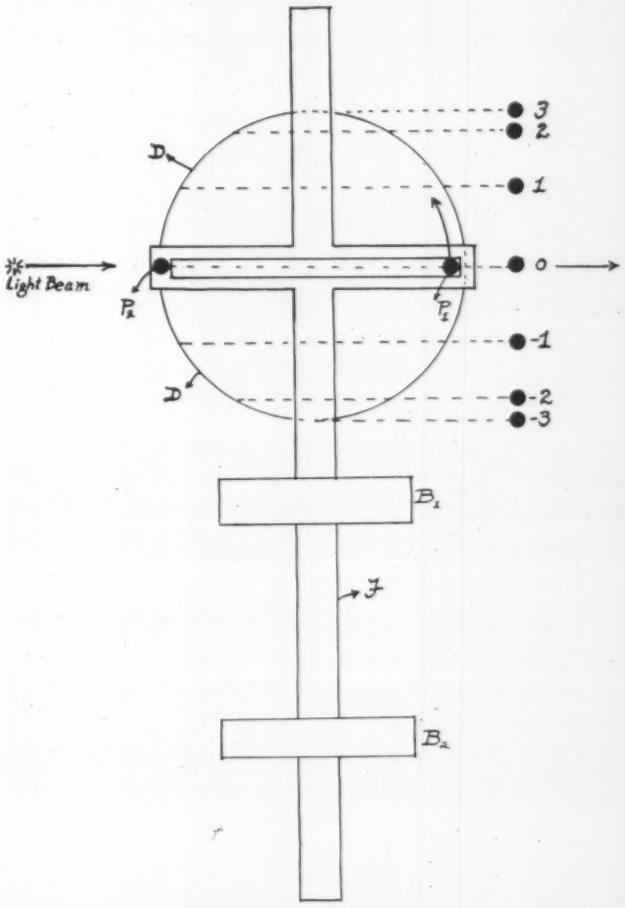

Fig. 10. Apparatus for showing relation between projection of uniform circular motion and simple harmonic motion. This is a cam which will give SHM.

frame, F. Consider a radius vector connecting the center of the disk and the pin, P_1. When this radius vector makes angles of 0°, 30°, 60°, and 90° with the horizontal, the projected position of the pin will be 0, 1, 2, and 3 respectively shown at the right of the figure. It is a case of SHM. This position or displacement from the central horizontal position is given by the equation: $Y = r \sin \phi$, the equation of a sine curve like that shown in Fig. 9.

Attached to the frame, F, is another pin, P_2. Fig. 11 shows an actual photograph of this equipment. If this outfit is now placed vertically and in the path of a beam of light so that an image of the machine may be cast on a distant screen by a lens, it will be observed that the images of the two pins seem to go up and down together as one, and yet one goes in a circle with uniform velocity, and the other is not only vibratory, it is SHM. Throwing an image of P_1 on the screen is projecting its motion; and so it is seen as SHM and is identical with the motion of P_2. It will be seen that P_2 at any instant is the projection of P_1 on the line along

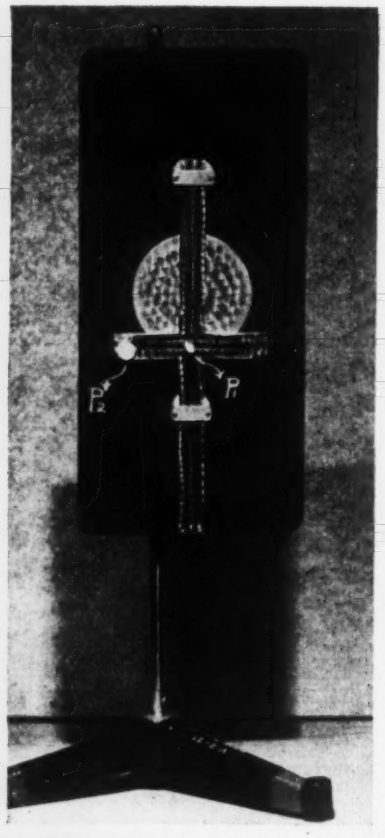

Fig. 11. Photograph of the apparatus given in a detailed drawing in Fig. 10.

which P_2 moves. By properly timing the speed of rotation of D, the pins P_1 and P_2 could be made to move up and down with the mass, M, in Fig. 3, showing that its motion was the same as SHM. If the frame F in Fig. 10 were continued on through the bearings, B_1 and B_2, to the piston rod of a steam engine, then the piston would move with simple harmonic motion. Fig. 12 will make clear the difference between the periodic motion made by a crank shaft on the piston of the engine and the periodic motion (SHM) made by the slotted bearing.

Demonstration of Lissajou's Figures. The Composition of Two SHM's at Right Angles to Each Other

Soller has combined two slotted frames like the one in Fig. 11 but with the two slots at right angles to each other. (See Figs. 13 and 14.) One carries a pen and the other a 10×15 centimeter card. The pen writes upon the card and, as a result, the two SHM movements at right angles to each other are recorded as a composition of the two. Fig. 13 shows some of these Lissajou figures drawn by Soller's instrument. Frequency, amplitude, and phase difference may be changed for each SHM.

By an ingenious arrangement the two SHM's may be combined in a parallel direction. When these combined

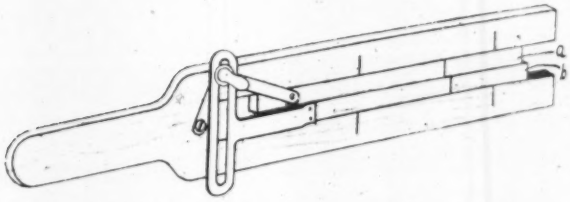

Fig. 12. This device shows that the piston (*a*) of a steam engine is not exactly SHM although periodic. The piston (*b*) driven by the slot is SHM. *(Courtesy W. M. Welch Co., Chicago, Ill.)*

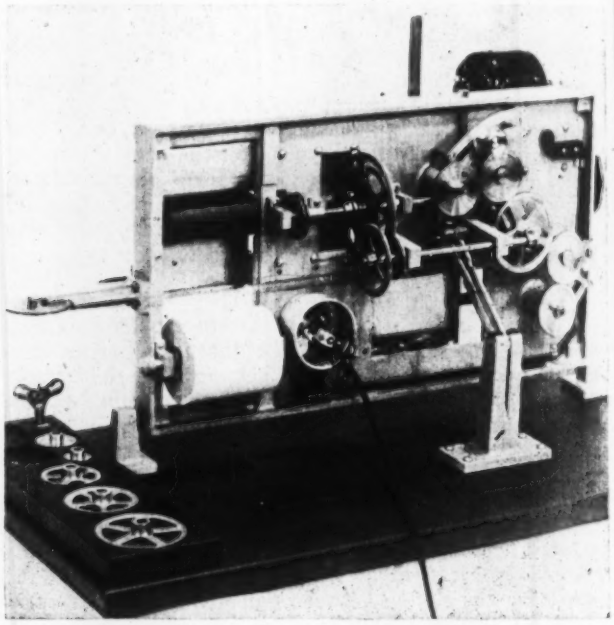

Fig. 13. The driving mechanism of Soller's simple harmonic curve tracer. Different gear wheels may be substituted to give different ratios of frequencies. Amplitudes and phase differences may be varied.

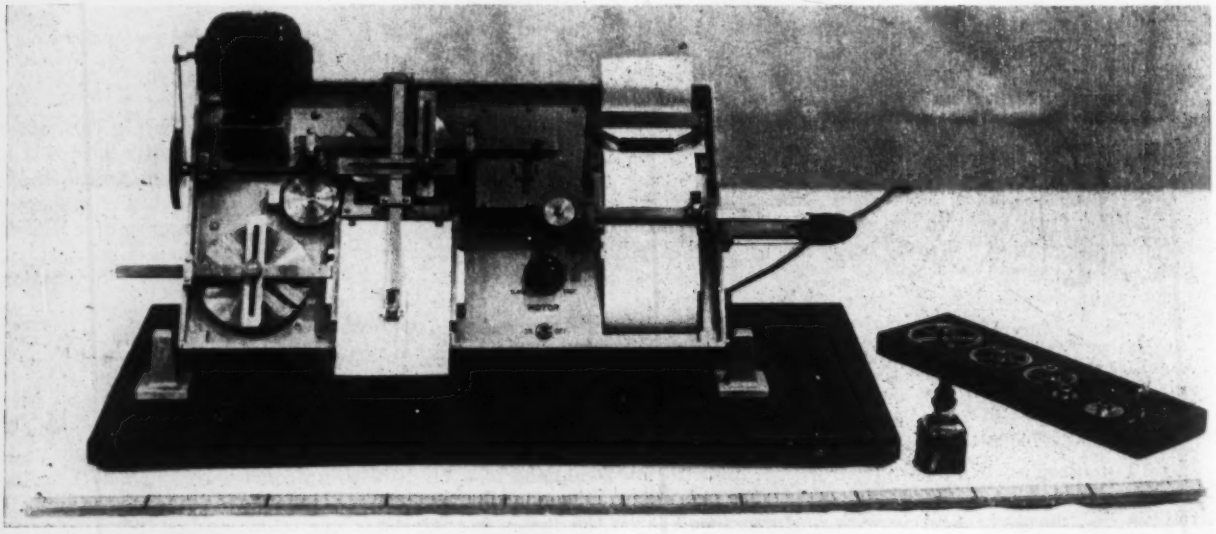

Fig. 14. Soller's harmonic curve tracer. On card at left are traced Lissajou's figures. On roll of paper at right are traced combinations of parallel simple harmonic motions.

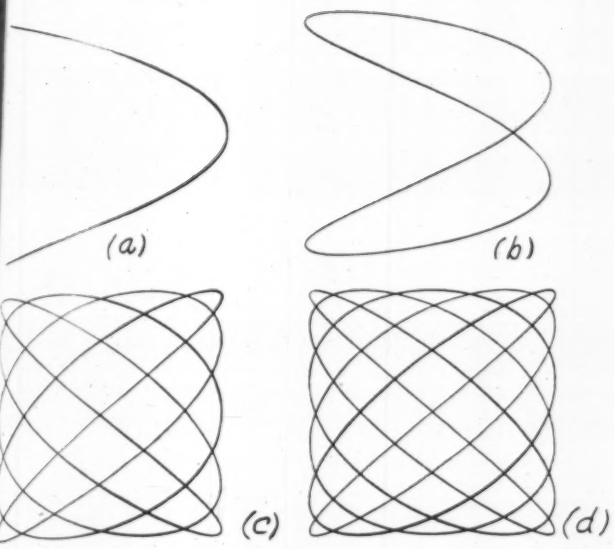

Fig. 15.
(*a*) Frequencies 2:1; amplitudes equal; phase difference 90°.
(*b*) Frequencies 2:1; amplitudes equal; phase difference 45°.
(*c*) Frequencies 5:4; amplitudes equal; phase difference 0°.
(*d*) Frequencies 6:5; amplitudes equal; phase difference 0°.

SHM's are then compounded with uniform linear motion at right angles to the combined SHM's, curves like those shown in Fig. 16 are produced, which give the resultant displacement of the two SHM's with respect to the time. The curves in Fig. 15 correspond to those in Fig. 16.

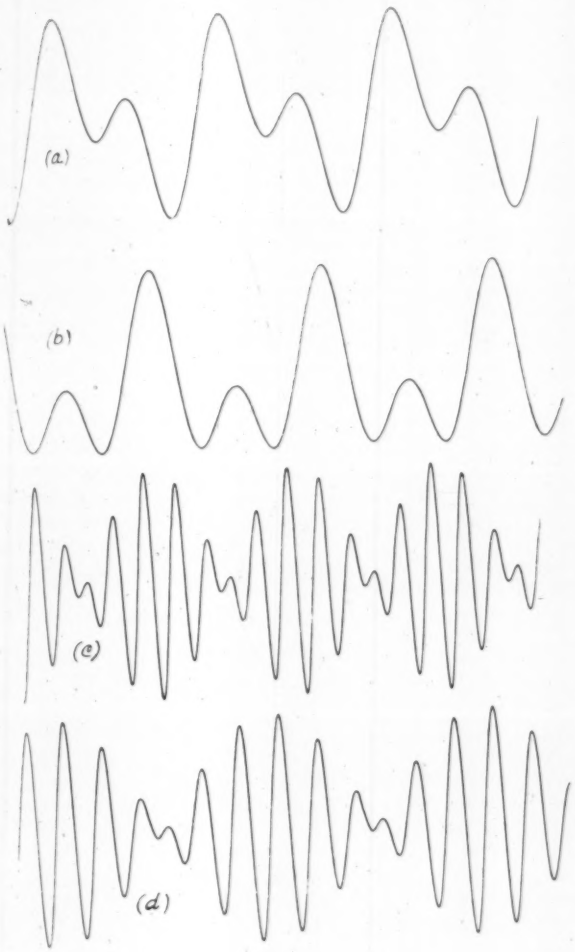

Fig. 16.
(*a*) Frequencies 2:1; amplitudes equal; phase difference 45°.
(*b*) Frequencies 2:1; amplitudes equal; phase difference 90°.
(*c*) Frequencies 5:4; amplitudes equal; phase difference 0°.
(*d*) Frequencies 6:5; amplitudes equal; phase difference 0°.

Demonstration of Maximum and Minimum Positions of Velocity and Acceleration in SHM

In order to help visualize the fact that in SHM the velocity is at a maximum when the acceleration is a minimum and vice versa, a rotating disk, *D*, with a pin, *P*, is rotated in a beam of light and by means of the lens, *L*, an image of the disk and pin is thrown upon the screen. (The arrangement of equipment is shown in Figs. 17 and 18.) As a result of this arrangement, the motion of the pin in uniform circular motion, projected upon the screen, makes the image move across the screen with SHM. At the end of the vibration the letter *A*, attached to the pin, *P*, comes into view, showing that at that point the acceleration is a maximum, while at the zero position a *V* comes into view showing that at the middle of the vibration the velocity is a maximum.

The importance of SHM will be further emphasized when we look into the properties of all types of wave motion in sound, heat, light, alternating currents of electricity, and radio.

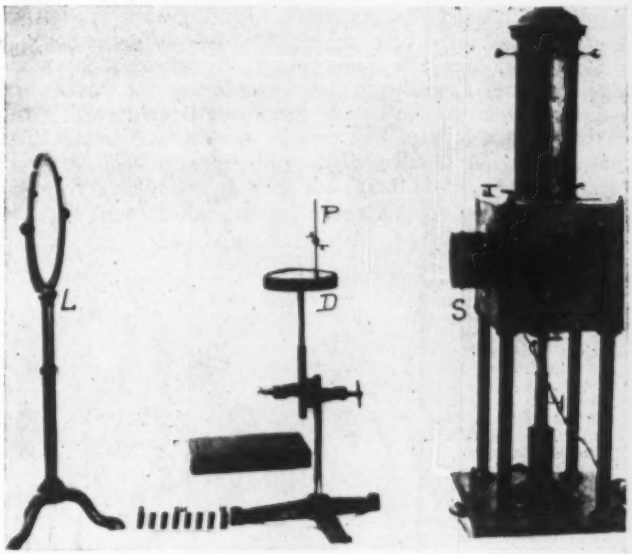

Fig. 17. As the disk *D* is rotated with uniform angular velocity, the pin *P* will move in a circle with uniform speed When projected on a screen by the lens *L*, the image of the pin moves with SHM.

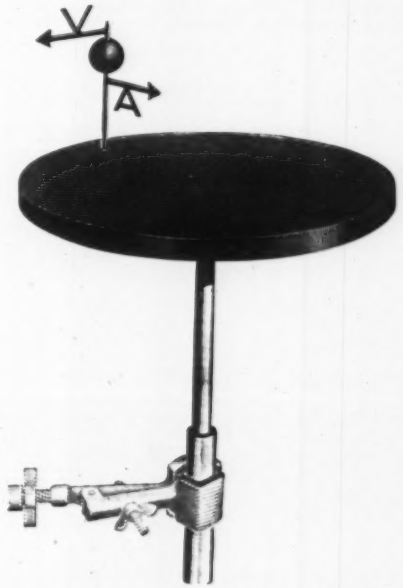

Fig. 18. This is a close-up of the device shown in Fig. 17. Here only the disk *D* and the pin *P* are shown. The arrows at any instant represent the velocity and acceleration of the ball in the SHM which it is producing on the screen. At the mid-point of its path the vector A is zero and the vector V is a maximum. These conditions are reversed as the ball moves to the end of its path in SHM. *(Courtesy Central Scientific Co., Chicago, Ill.)*

ELECTRON TUBES

Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER
Managing Editor, *Power Plant Engineering*, Chicago, Ill.

CHAPTER VI
IONIZATION

Before continuing the discussion of the three-electrode tube, it will be expedient to consider briefly another aspect of electron tube phenomena which in recent years has grown to be of prime importance. This other aspect of electron tube action applies to diodes and other classes of tubes as well as to triodes.

In all of the tubes considered so far, regardless of whether or not a grid was present, the space between the cathode and the anode has been assumed to be empty, that is, a vacuum. Of course, no space within any tube ever made has been a real vacuum; with the best evacuating methods available, there are millions of gas molecules per cubic centimeter. For most practical purposes, however, such vacuums are adequate and insofar as the passage of electrons from the cathode to the anode is concerned, tubes containing such vacuums can be considered empty. The molecules are so small and the space between them so great in comparison with their size that it is only very rarely that an electron will encounter a molecule in such rarefied

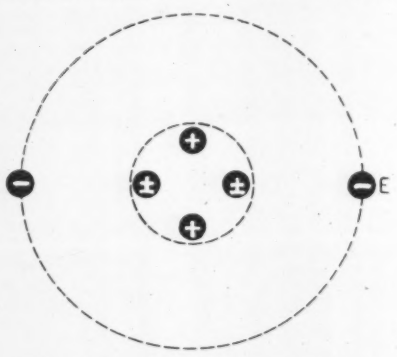

Fig. 36. Conventional diagram of the neutral helium atom. It consists of a nucleus in which are disposed in close proximity two positively charged protons and two neutrons carrying no charges. At a distance from this nucleus, two external electrons revolve in a closed orbit as shown. The negative charge of these two external electrons compensates for the excess positive charge of the nucleus.

atmospheres. (Even in a very good vacuum, say 10^{-7} mm. Hg., there are still about 10^9 gas molecules per cm.^{3} which means that their average distance is only 10^{-3} cm. This distance, however, is equal to 100,000 times the diameter of the atom.)

A natural question that comes to mind is this: If, instead of a vacuum, a relatively large amount of gas were left in the tube, how would this affect the tube's operation?

As can be readily imagined, the operation would differ materially from that of the high-vacuum tube, for there is no longer a clear path for the electrons in their passage from the cathode to the anode; and many if not all of the emitted electrons will collide with gas molecules. The molecules, however, and also the atoms of even the lightest gases (hydrogen and helium) are hundreds and thousands of times more massive than electrons and, in the absence of more specific knowledge, it would be reasonable to suppose that when an electron collides with an atom or a molecule the electron would be stopped and would never reach the plate. To a certain extent, of course, this is true but it does not take into account the process known as "ionization."

To explain this it is necessary to revert, briefly, to some of the fundamental facts regarding the structure of matter. All matter is composed of molecules or atoms—the molecules being groups of atoms. An atom is a complex system consisting of a central portion—the nucleus—surrounded by one or more electrons revolving in closed orbits. It is similar to a tiny solar system with a sun at its center surrounded by one or more planets. In Fig. 36, for example, is shown a conventional diagram of a helium atom. The helium atom has been selected for this illustration because it happens to be one of the simplest atoms, structurally, but the principles to be described apply in the case of any other atom.

The helium atom consists of a nucleus containing four particles in close proximity, around which revolve in an external orbit, two other particles called electrons. The nucleus consists of two protons and two neutrons. These protons and neutrons are much alike except for one thing, the protons carry unit positive electrical charges while the neutrons are electrically neutral, i.e., they carry no charge. These are of substantially the same weight and size as the protons. Since it contains two protons, the nucleus as a whole exhibits a positive charge of 2. It is because of this positive charge of 2 that the helium atom has 2 electrons in its external orbit. Electrons carry unit negative charges and these 2 negative charges, therefore, satisfy the requirements of the 2 positive charges in the nucleus. The atom as a whole is electrically neutral.

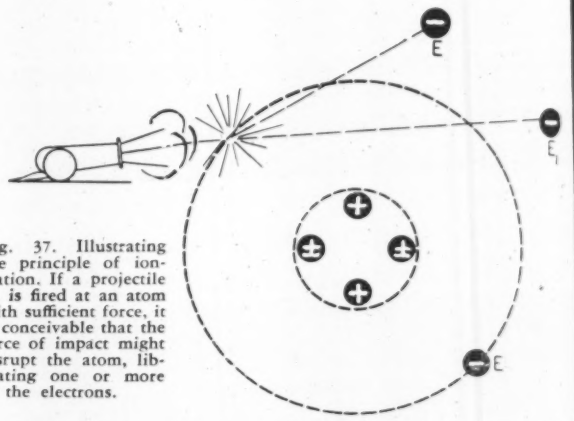

Fig. 37. Illustrating the principle of ionization. If a projectile E, is fired at an atom with sufficient force, it is conceivable that the force of impact might disrupt the atom, liberating one or more of the electrons.

The helium atom, though simple, is not the simplest. The simplest of all atoms is the ordinary hydrogen atom whose nucleus consist of a single proton, and which has but one electron. Next in the order of complexity is the heavy hydrogen atom whose nucleus contains one proton and one neutron. Again, there is but one atomic electron, hence the chemical properties are those of hydrogen, although the atomic weight is about twice that of ordinary hydrogen. It must be understood that the chemical properties of an atom are due to the number of protons in the nucleus. Also, the number of electrons that an atom possesses when in its normal state is always equal to the number of protons in the nucleus. The proton, though it carries the same unit charge as the electron, is 1847 times more massive.

The Process of Ionization

The electrons (which are always disposed in one or more orbits external to the nucleus), however, are quite loosely bound to the nucleus and if sufficient force is applied they can be removed from the atom. For the sake of illustration suppose a small high-speed projectile E_1 is fired at the atom as shown in Fig. 37 and that this projectile collides with one of the orbital electrons E as indicated. If the energy involved in the collision is sufficiently great, the orbital electron E will be knocked clear out of the atom, leaving the atom deficient of one electron. Under these conditions the atom is said to be ionized and of course exhibits a positive electric charge. The electron which has been knocked out of the atom is for the time being a "free" electron and will be attracted by any positive charge it may encounter. The "ionized" atom will tend to regain the lost electron at the earliest opportunity.

The Effect of Ionization in a Gas-filled Tube

This is a rather crude way of explaining it, but this is essentially what occurs in a tube in which gas is present. Instead of the gun shown in Fig. 37 there is a cathode surface emitting electrons. These electrons are acted upon by the electrostatic field existing between the cathode and the anode and they are accelerated by that field in the direction of the anode.[1] The space between the cathode and the anode, however, contains large numbers of atoms and so there is considerable probability of an electron colliding with an atom before it reaches the plate. If, at the time this collision occurs, the electron has acquired sufficient velocity, it will strike with such force as to remove one or more of the orbital electrons from the atom, leaving the latter ionized.

This action is known as ionization by collision[2] and it plays an extremely important role, not only in electron tubes, but in all electric arc phenomena.[3]

Consider, for example, the action of the presence of gas in a two-element tube, a diode. Such a tube is shown, diagrammatically, in Fig. 38 and for the sake of simplicity we shall consider the action resulting from the emission of a single electron, *e*, from the cathode at the point *A* as indicated. In an actual tube, of course, millions of such electrons are emitted from all parts of the cathode surface but, here, we will ignore all of them except just the single one shown and we shall follow it in its journey toward the plate.

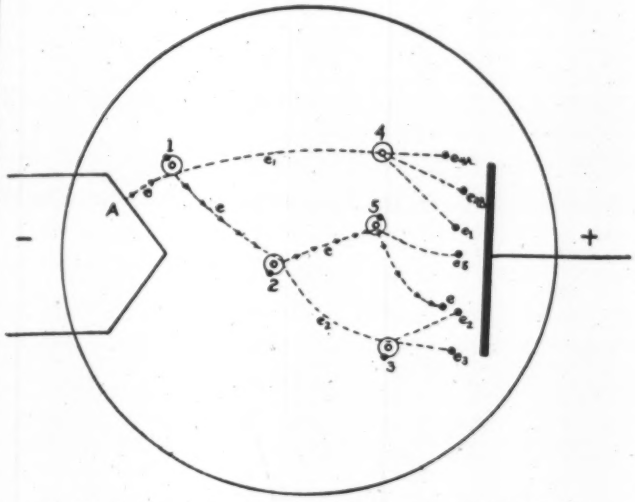

Fig. 38. The effect of ionization in a gaseous tube. A single electron e emitted from the cathode at A is accelerated by the positive field until it collides with atom 1. Here the force of collision liberates electron e, which also is accelerated by the field until it disrupts atom 4, liberating two additional electrons, e_{4A} and e_{4B} The original electron e in the meantime has ionized atoms 2 and 5, and the product of the ionization of atom 2 in turn has ionized atom 3. The net result of these successive collisions, therefore is that instead of a single electron, we have seven electrons reaching the plate.

An instant after the electron emerges into the space between the cathode and the plate it is acted upon by the positive field due to the plate and it is accelerated along the path shown. At point 1, however, it collides with an atom and strikes it with such force as to dislodge one of the electrons e_1 normally belonging to that atom. This electron e_1 is also acted upon by the field due to the plate and therefore is also accelerated in a direction toward the plate. At point 4, however, this "freed" electron also collides with another atom of gas and in this case the force of impact is so great (for the electron has acquired great velocity) that not one, but two electrons, e_{4A} and e_{4B}, are liberated. These then are also attracted to the plate.

In the meantime, the original electron, *e*, after having ionized atom 1, has been deflected somewhat from its original course but still under the influence of the positive field, has traveled to atom 2 where a similar action has taken place. As a result, electron e_2 has been liberated, which then collides with atom 3 where the process is again repeated. The original electron, *e*, again has gone on and ionized atom 5.

Further explanation is unnecessary. It should be apparent that though only one electron left the cathode, as a result of its successive encounters with atoms and the consequent liberation of new electrons, not one but seven electrons finally reach the plate. It also must be evident that a tube in which this action occurs will carry far greater currents than tubes without gas—tubes in which this disruption of atoms does not occur. For electrons are carriers of electricity—indeed they *are* electricity—and the greater their number, the greater the magnitude of the current.

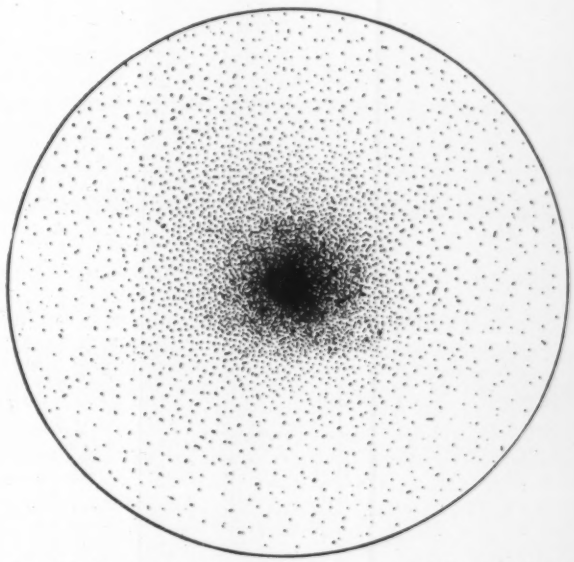

Fig. 39. Distribution of electrons around a cylindrical cathode placed at the center of a cylindrical anode.

The production of these additional electrons, however, is not the only effect of ionization. What, one may ask, becomes of the residue of the atom?

The answer to this question is relatively simple. An atom, after losing an electron, is positively charged and it will migrate toward the cathode which is negatively charged with respect to the plate. The atom, however, may be thousands of times more massive than the electron and since its charge is no greater, the speed of its migration toward the cathode will be slow, so slow in fact that this drift of positively charged elements contributes little towards increasing the magnitude of the current.[4] It has an important effect,

(1) Another way of looking at this is to think of the electrons as moving from a place of excess to one of deficiency in the same way that a crowd of people move into the empty seats of a theater. The plate is continually deficient in electrons because it is connected to the positive terminal of a battery.

(2) Ionization can be accomplished in other ways also, i.e., thermally for example, where the removal of electrons is the result of thermal agitation of the molecules or electrolytically, in which case the dissociation is due to the attractive influence of neighboring molecules of water. In a salt solution, for instance, ions are formed spontaneously without the aid of an electric field.

(3) For detailed information see Theories of the Electric Arc in the author's book *Electricity—What It Is and How It Acts*, Vol. 1, p. 250.

(4) A conception of the order of atom, electron and ion speeds is given by E. D. McArthur of the General Electric Co. in his book *Electronics and Electron Tubes*, as follows: (1) The mean speed of a mercury atom in a container at a temperature of 60°C. is 0.12 miles per second. This is the ordinary molecular speed due to temperature. (2) The speed of an electron after being accelerated by a potential difference of one volt is 368 miles per second. (3) Under the same 1-volt difference of rotential, however, the speed of the mercury ion, after being accelerated, is only 0.6 mile per second.

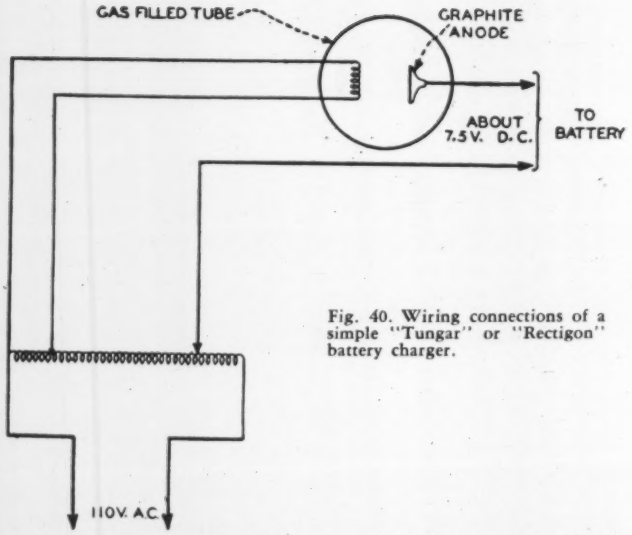

Fig. 40. Wiring connections of a simple "Tungar" or "Rectigon" battery charger.

however, in that it neutralizes part of the negative "space charge" which surrounds the cathode and which, in high-vacuum tubes, limits the transportation of electricity from cathode to plate.

Space Charge

Briefly, space charge is the resultant negative charge of all the electrons in the immediate vicinity of the cathode. In Fig. 39 is depicted the relative distribution of electrons around a cylindrical thermionic cathode placed at the center of a cylindrical anode. The density of electrons, it will be noted, is much greater in the immediate vicinity of the cathode than it is at distances further removed, in fact the cathode is surrounded by a virtual "cloud" of electrons. This cloud, by virtue of its negative influence, exerts a repelling effect upon other electrons tending to emerge from the cathode surface. This action holds for high-vacuum type tubes as well as those containing gas.

The effect of this cloud of electrons is usually referred to as the space charge and its presence constitutes a limiting influence upon the space current through the tube. For it is evident that if there is a force tending to keep the electrons from emerging from the cathode, the electron current cannot attain the value that it would have if this retarding influence were not present. Any method of reducing or neutralizing this space charge, therefore, will benefit the performance of the tube.

Understanding this, the function of the positive ions resulting from the ionization process described becomes evident. As the positively charged atoms approach the cathode, their fields neutralize the fields of the electrons and thus the space charge is partly neutralized. The greater the degree of neutralization, the more does it aid the emission process.

Thus, although the production of additional carriers (electrons) is an important effect of ionization in a gas-filled tube, the more important effect is the neutralization of the space charge.

Practical Applications

The effect of introducing gas into thermionic tubes, therefore, is to enormously increase the current-carrying capacity. In such tubes currents are measured not in micro- or milliamperes as in the case of high-vacuum tubes, but in amperes and even hundreds of amperes in large power tubes. Such tubes (two-element gas-filled tubes) therefore, are used for rectifying alternating current for power purposes. The ordinary small battery-charging rectifier such as the Tungar[5] and Rectigon[6] chargers use tubes of this type. These tubes are characterized by a heavy tungsten filament acting as a cathode heated to a high temperature to make it yield high emission: about ten times that obtainable in high-vacuum tubes. Enough argon gas is admitted to the tube to prevent evaporation of the filament at this high temperature.

(5) General Electric.
(6) Westinghouse.

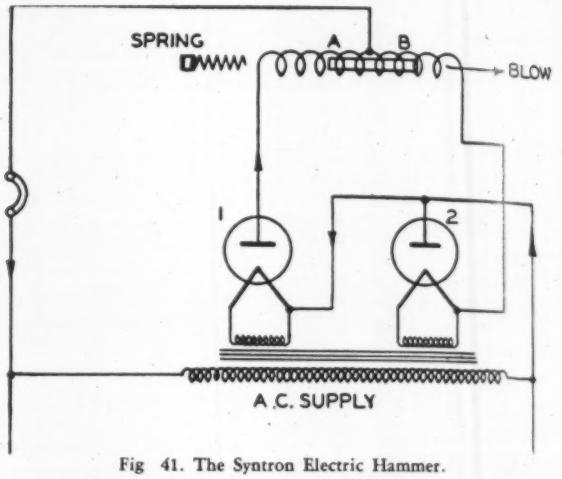

Fig 41. The Syntron Electric Hammer.

The circuit of such a battery charger is shown in Fig. 40. 110-volt a.c. is supplied to a small auto-transformer which supplies both the filament current and the plate. Only a low voltage (1.8 volt) is necessary for the filament so only a few turns of the transformer are used to supply this voltage. This circuit, of course, provides half-wave rectification. For full-wave rectification, two tubes are used in a circuit such as shown in Chapter III, Fig. 15 or Fig. 16.

While the introduction of gas into a thermionic tube greatly increases its current-carrying capacity, it at the same time so alters the characteristics of the tube as to make its application quite different from those of the high-vacuum type. Thus far we have only considered the use of gas in two-element tubes, and in these tubes the use of gas has not altered its function materially, such tubes are still rectifiers as is the high-vacuum two-element tube. When we come to discuss three-element gaseous tubes, however, we shall see that the presence of gas entirely changes the functions of the tube and adapts it to an entirely different set of purposes.

Because of the use of gas in a two-element tube so greatly increases its current-carrying capacity, it adapts the tube to power purposes. Indeed, the well-known mercury arc rectifier used for many years in the railway field is a tube which operates on these same principles except that the electron emission is obtained not from a heated cathode but from a pool of liquid mercury. If an arc is formed between such a pool and another electrode, a "cathodic" spot is formed which furnishes an intense source of electrons.

Other forms of mercury vapor rectifiers use hot cathodes just as the Tungar and Rectigon tubes described, but these tubes, instead of being filled with argon, are filled with mercury vapor. During manufacture, after being thoroughly exhausted, a small quantity of mercury is placed in their interior. Later, when in use, as the cathode is heated, this mercury evaporates and the tube fills with mercury vapor, at a pressure which depends directly upon the coolest part of the tube's walls. At the coolest spot on the wall the mercury vapor condenses; hence the temperature of this spot is the principal factor which controls the pressure to which the mercury evaporates.

In the case of mercury vapor tubes the voltage required to ionize the mercury is 10.4 volts.[7] The actual voltage maintained across the tube in practice is about 15 volts.

Concluded on page 634

(7) Each type of atom has what is called ionization potential. This is the least energy, expressed in electron volts, required to completely remove an electron from an atom. Inasmuch as all atoms but hydrogen contain more than one electron, an atom may have more than one ionization potential. The first ionization potential applies to the removal of an electron from a normal atom; the second ionization potential involves the removal of a second electron from an atom that has already lost one electron. Thus in the case of the mercury atom, it takes an energy of 10.4 electron volts to remove the first electron. An electron volt, it should be understood, is the amount of energy gained by an electron when accelerated in free space through a difference of potential of 1 volt.

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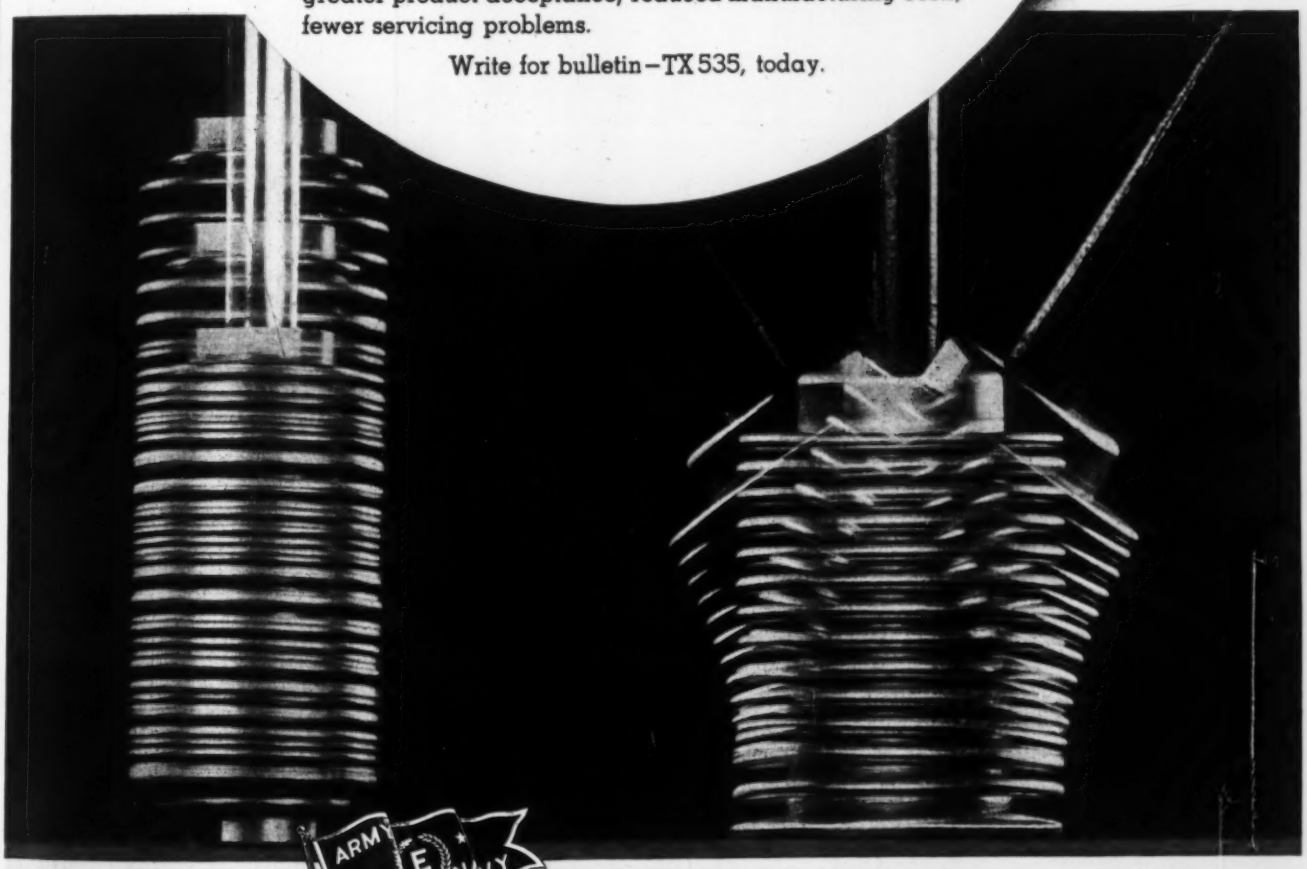

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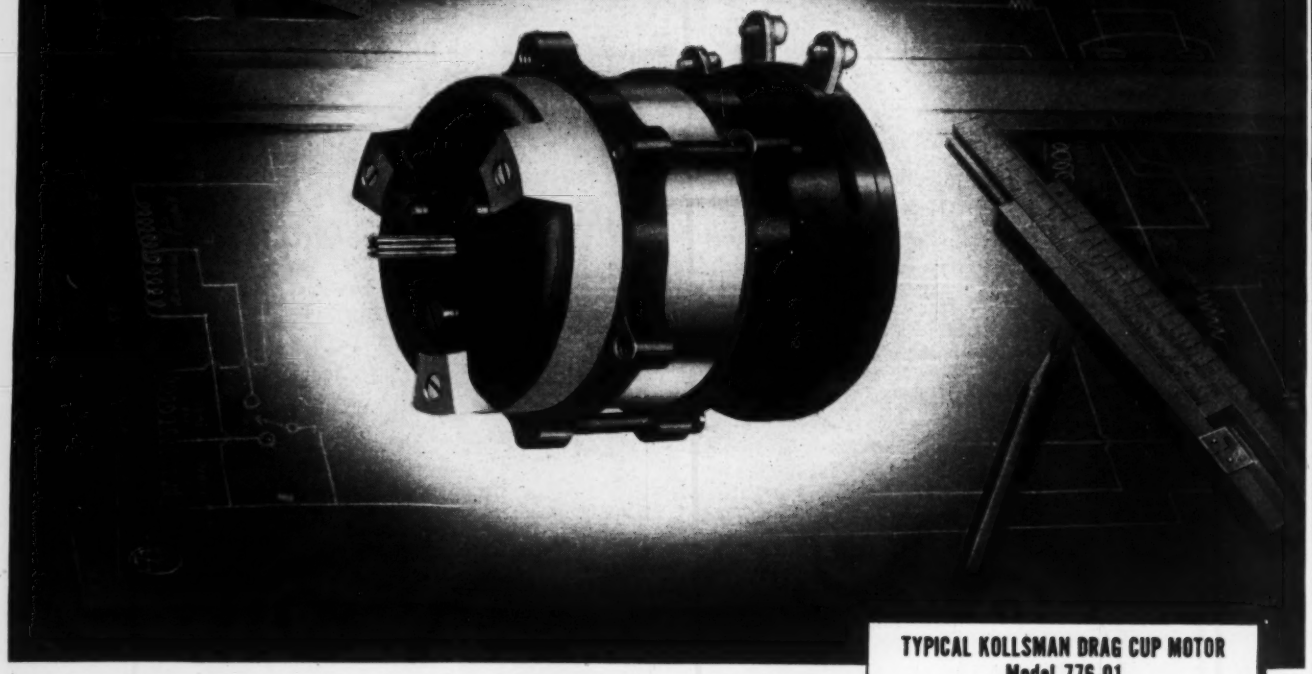

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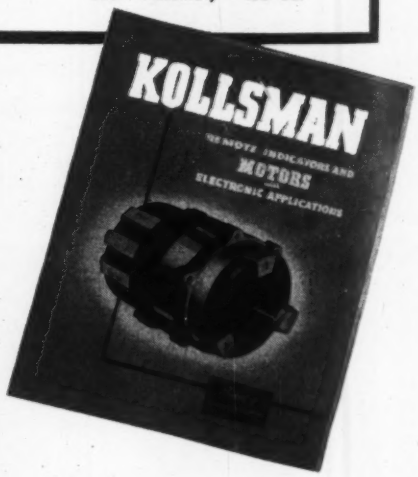

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Vol. II, No. 10 Guest Editor: Harry Gollob October 1943

IMPROVE! STANDARDIZE! CERTIFY!

Editorial by **HARRY GOLLOB,** *Guest Editor*

Head Aviation Instrument Dep't, Defense Training School for War Workers
New Mexico State College of Agriculture and Mechanics Arts, State College, N. M.

TODAY, the need for organization of the aircraft instrument field is more pressing than ever: establishing of standard courses of study; establishing of requirement and qualification of instructors; a simplified qualification rating of aircraft instrument mechanics; establishment of a standard chart of repair and overhaul charges or rates; establishing standard qualifications of instrument repair shops.

In the following I shall attempt to present details regarding the above suggestions.

Establishing standards for courses of study will demand coöperation of the many aircraft instrument schools in order to "level out" and "balance" the subjects to be taught in a clear simplified form or outline. It will necessitate the past experiences of both the institutions and instructors in formulating this outline.

Standardizing the courses does *not* mean that one school should give all of its *detailed* course of instruction to another or all other schools. But the idea is to establish a *detailed outline* of the course of aircraft instruments, so that any student graduating from any certified institution will be assured of equality with his fellow worker (of the same rating) in ability and training. This alone will tend to promote coöperation and mutual respect among the aircraft instrument mechanics.

WHENEVER we have a Guest Editor we use this space for his photograph and biography. Mr. Gollob sent us his photograph (after we insisted) but at the moment of going to press we have not yet received his biography. He finally overcame his modesty to the extent of giving us just a few facts about himself, but without any clues as to the beginnings and ends of his experiences. For example he mentions "import and export (Mexico)" and also "Licensed CAA Ground Instructor in Aircraft Instruments" but without dates. However, he mentions also "Age 41" and "Aeronautics." and this, together with other one-word clues, gives us the impression that up to the outbreak of war in Europe, his vocation was business and his avocations were radio and aviation. We can imagine his "hobbies" triumphing, for he mentions graduating from the American School of Aircraft Instruments (which is located in Glendale, Calif.) This must have been several years ago, for he worked and taught aircraft instruments in several places: the Naval Air Base at Corpus Christi, Texas; Army Air Bases at Deming, N. M.; Kirtland Field; Randolph Field, and Biggs Field. He did not give us the date when he came to New Mexico State College but his present jobs there are Head of Aircraft Instrument Department and Chief Instructor in Aircraft Instruments. He recently wrote us that the College "is carrying on a triple program: Army cadets, regular courses and National Defense Training School and all professors, deans and instructors are being taxed to the limit for time"—in spite of which obstacles he got four of them to write the four articles which follow his own (pages 610 to 624); and from *this* we get the impression that Mr. Gollob is not only a good teacher but, thanks to his pre-war business experience, a good executive!—M. F. BEHAR, Editor of *Instruments*.

The outline of the course for aircraft instrument repair, overhaul, installation, etc., which the writer planned and prepared. and which is being offered* at the New Mexico State College of Agriculture and Mechanic Arts Defense Training School for War Production Workers, is as follows:

I. Tools—Safety

A. Hand tools, precision, use of eye loupe.
   1. How to select proper tools, when and how to use same, and care of same.
      a. Theory, charts, demonstration.

B. Hammers, files, vises, soldering irons, wrenches, etc.
   1. How to select proper tool, when and how to use; care.
      a. Theory, charts, demonstrations.

C. Elementary instruction in operating jeweler's lathe, small bench lathe, drill press, grinding wheels.
   a. Theory, charts, demonstrations.

D. Cleaning fluids, lubricants, drying process (air hose), polishing compound, radium paint.
   1. Name, purpose, and how to use cleaning fluids;
   2. Precautions and dangers of cleaning fluids;
   3. Names and use of lubricants;
   4. Names and use of sealing compounds;
   5. Polishing compounds, stones, and how to use same;
   6. Advantages of air hose for drying—
      a. Dangers of misuse of air hose pressure.
   7. Radium—
      a. Cleaning — scraping process;
      b. Painting with radium and phosphorescent paint;
      c. Precautions

E. Care of work bench
   1. Cleanliness
   2. Arrangement of tools on same at all times during working hours

II. Equipment

A. Manometers
   1. Water
      a. Purpose, when, and how to use with instruments
   2. Mercury
      a. Purpose, when, and how to use with instruments

B. Vacuum chamber, bell jars, and pump

C. Turn and Bank stand
   1. Purpose and how to use

*The course is offered free to any American boy or girl, man or woman, from 16 years of age up.

D. Temperature Gage test units
   1. How to use same
E. Electrical test equipment
   1. Purpose and use of same

III. Basic Instrument Parts
(Lectures, charts, demonstration)

A. "Motor" Equivalent
   1. Diaphrams—Aneroids
      a. Construction and functioning
      b. Elementary meteorology (Barometric pressures, etc.)
   2. Bourdon tube and vapor pressure bulbs
      a. Construction and functioning
   3. Gyro wheels
      a. Gyroscope principle
      b. Description of various types
   4. Magnets
      a. Basic principles of electricity
      b. Types of magnets (permanent and electro-magnets)
      c. Wheatstone bridge
   5. Radio (elementary or basic principles)
B. Linkage Systems
   1. "Bridges"
   2. Rocking bar shafts
   3. Sector gears
   4. Hand shafts
   5. Hair springs
      a. Use, repair, and setting
   6. Pivots and pivot screws
      a. Polishing and checking
   7. Bearings and races
   8. Gears
   9. Damping
   10. Temperature compensation
   11. Centrifugal force (flyweights)
   12. Springs
      a. Leaf
      b. Tension and pressure—coil
   13. Pistons and piston cylinder assembly
      a. Construction and function
C. Physics—Elementary, Leverages, Weights, etc.
D. Dials and Indicating Pointers
   1. Types and sizes of dials;
   2. Types and sizes of hands—
      a. Checking and balancing of hands.

IV. Instruments
(Lecture, charts, demonstration)

A. Oil and Fuel Gages
   1. Theory; purposes and uses of same; principle of operation;
   2. Test on test stand—
      a. To understand condition of instrument before disassembly.
   3. Disassembly—
      a. Correct procedure.
   4. Repair and clean—
      a Check for defective parts or wornout parts;
      b. Clean and repair.
   5. Reassemble—
      a. Correct procedure.
   6. Calibrate;
   7. Final check—
      a. Perfection in operation—neatness and cleanliness of entire unit and case.
B. Pressure Gages—Vapor Bulb
   1. Purpose, uses, advantages. Principle of operation;
   2. Procedure as in IV-A. Review III-A-2. Testing as described in II-1
C. Airspeed
   1. Purpose, uses, advantages; principle of operation;
   2. Review III-A-1;
   3. Source of "energy";
   4. Procedure as above instruments.
D. Pitot Tubes and Venturi Tubes
   1. Purpose, uses, advantages; principle of operation;
   2. Instruments connected to each;
   3. Clean and test;
   4. Types.
E. Manifold Pressure
   Procedure as in IV-A. Review III-A-1.
F. Altimeters
   Procedure as in IV-A. Review III-A-1.
G. Rate of Climb
   Procedure as in IV-A.
H. Suction Gage
   Procedure as in IV-A.
I. Compass—Magnetic
   Review III-A-4. Procedure as in IV-A.
J. Tachometer—Centrifugal
   Procedure as in IV-A. Review III-B.
K. Tachometers—Electrical
   Procedure as in IV-A. Review III-B.
L. Tachometers—Electrical-chronometric
   Procedure as in IV-A. Review III-B.
M. Tachometers—Chronometric
   Procedure as in IV-A. Review III-B.
N. Fuel Level Gages
   Procedure as in IV-B. Review III-B and III-C.
O. Electrical Gages
   Procedure as in IV-A. Review II-E and III-A-4.
P. Radio Compass
   Procedure as in IV-A. Review II-E and III-A-5.
   1. Navigation
Q. Autosyn, Telegon, Selsyn
R. Pioneer Turn and Bank
   Procedure as in IV-A. Review III-A-3.
S. Directional Gyro
T. Gyro Horizon
U. C-1 Test Set
V. Plumbing
W. Installations and Bonding
X. "Line Checks"

The material of which this course is compiled has been gathered from manufacturers' manuals and various books which have been published in the past few years, plus the writers' personal experience working on the bench and "on the line" at U. S. Naval and Army Air Base Repair Depots.

In the above outline you will notice

I. Tools, Safety
II. Equipment

I have learned through experience and especially with the aid of the Job Instruction Training which I received, that *unusual* speed in learning and exceptionally greater efficiency result when a student is actually taught first how and when and what tool to select, how to hold it, how to use it and why; also the correct use and misuse, and why. Similar instruction is likewise given on each piece of equipment.

This method may strike you as more or less of a method for young children but it is the key to efficiency and speed. When tools and equipment are taught and learned thoroughly, more than half of the instructor's entire work has been efficiently completed. A mechanic can repair parts of an instrument with the proper use of plier or tweezer if he understands the tool and how to use it; likewise he can ruin the part of an instrument due to his lack of complete knowledge of how to use this same tool.

On equipment: An airgun can destroy plenty of instruments in untrained hands. Hazards are always present when people (ignorantly) scrape radium or luminous materials from dials and indicator hands while "cleaning up" the instrument, etc.

Hence, Tools, Safety, and Equipment are listed as the first subjects of the instrument repair course.

Now for the department of instructors! The War emergency has caused great laxity in the field of instruction, but regulations should tighten up a bit. Responsibility for the students' education rests heavily on the instructor. An instructor in aircraft instruments should know his work thoroughly—"book learning" (theory) *plus* actual mechanical experience on the "bench" and/or on the "line." It is more or less a simple matter to read a lecture from a book or pamphlet and explain the theory, etc., with a "mock-up" or a demonstration unit built for instructional purposes. But it is a more serious and necessary requirement to be able *to explain* and to work with the students on other regular units which are not merely made up for instructional and demonstrational purposes.

A good rule from Job Instruction Training—"If the student has not learned, then the instructor has not taught"—holds true in a high percentage of incidence.

In order that the instructor may be able to answer most questions put by the alert aircraft instrument student, it

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will be of great advantage for the instructor to possess at least a fair knowledge of physics, electricity, radio, meteorology, navigation and flying.

Requirements of instructors may be listed as follows:

A. For teaching theory—
   1. Completion of thorough course in theory of aircraft instruments
   2. Fair knowledge of physics, electricity, meteorology, radio, principles of flying, and navigation
   3. Familiarity with bench work and line work.

B. For teaching bench work—
   1. Completion of thorough course in theory
   2. Experience in actual bench work on any and all aircraft instruments about which he teaches. He should have actually overhauled and repaired these instruments during his period of experience.
   3. Thorough knowledge of the use, handling, and respect of tools, equipment, and instruments.
   4. Experience in shop maintenance.
   5. Ability and willingness to teach (transfer his knowledge to student) student all the "tricks of the trade."

C. For teaching line work—
   1. Completion of thorough course in theory
   2. Knowledge of bench work.
   3. Thorough knowledge of the use, handling, and respect of tools, equipment, and instruments.
   4. Experience in shop maintenance.
   5. Ability and willingness to teach the student all the "tricks of the trade."
   6. Actual experience on "line work" on a variety of aircraft.

Now, a suggestion in regard to the classification of aircraft instrument mechanics. Each aircraft instrument mechanic should be required to be licensed by the Civil Aeronautics Administration the same as is an A. & E. mechanic. Examination required for license plus experience record. A log book should be kept by the mechanic of every instrument "handled," the "log" to be completely detailed:

A. Overhaul Ratings:

Electrical Instruments	A 1
Gyro Instruments (all types)	B 1
Standard Instruments	C 1
(Complete group)	I

B. Line Work Ratings:

Electrical Instruments	A 2
Gyro Instruments (all types)	B 2
Standard Instruments	C 2
(Complete group)	L

Establishing a standard of repair costs would necessitate close coöperation with instrument manufacturers—a program similar to the system used by the automotive trades (garages).

In the future, I believe we will have thousands of repair shops in most cities from coast to coast, possibly as numerous as garages today. Most of these shops will probably specialize in just one, two or three instruments. In order to prevent the mushroom growth of "monkey wrench mechanics," it will be necessary for the C.A.A. to plan regulations requiring *all* aircraft instrument repair shops and aircraft instrument mechanics to secure license or certification before repair shops be allowed to do work of any kind on aircraft instruments.

In fact, I believe that now is the time to put aircraft instrument work on a high level and or a sound basis, avoiding exclusive societies for the limited few. Now is the time that aircraft instrument manufacturers, schools, and institutions, should compile material to be presented to the C.A.A. for its consideration in "lining up the controls" on aircraft instrument maintenance and repair work.

An Adaptation of Dye Coupling for Color and Monochrome

By F. ROBERT POOLE
Physics Department, New Mexico State College of A. & M. A., State College, N. M.

THE appearance of Howard C. Colton's article, "Dye Coupling for Color and Monochrome" in the September 1939 issue of *Photo Technique* led the writer to feel that such couplers could be used directly in the formation of natural color prints on ordinary single-emulsion photoprint paper.

In the formation of a developed photoprint, only a small portion of the halide present is developed or reduced. Thus, within limits, if fixing does not take place between steps successive images can be exposed and developed, superimposed, on a single sheet of print paper. If three of these images are developed in dye-coupler color-formers, each color former being one of the three tricolors whose composition will correspond to eye sensitivity and the result of an exposure through its corresponding negative record, a natural color print will result. The negative records are the usual ones taken through red, green and blue filters and the developed images the corresponding subtractive colors of cyan, magenta and yellow.

The following is an adaptation of this plan which has yielded experimentally positive results. A basic developer was compounded which was complete except for the inclusion of an additional solution. Three of these additional solutions were prepared: one which would cause the development of a tricolor red, the other two of the tricolor magenta and the tricolor yellow. Formation of these developers is covered in Mr. Colton's article. In a darkroom, under ruby light, a piece of photo paper was soaked in plain water to take up the swelling. The paper was then supported on a piece of flat perforated metal and exposed through the red-filter negative and developed in the developer mixed for the formation of the cyan image. Without fixing, the print was then thoroughly washed in water and then again in acetone or alcohol to remove the unused color former. This was then followed with similar steps except that the second exposure was through the green record negative and developed in tricolor magenta developer and the third through the blue filter negative and developed in the tricolor yellow developer. Care must be used throughout in the registration of the images and the paper may be manipulated to make it conform in registration with the negative images. As a fourth step, the print is bleached to remove the silver images produced and this followed by fixation in a non-acid fixer. This sequence of color formation was selected so as to facilitate registration and to obtain the most desirable masking effects.

All controls or variables are readily obtainable in this process. The intensity of each color image can be varied by the concentration of the color former present as well as by the intensity of the exposure. Contrast can be modified by the use of more or less contrasty developing solution, which behaves in the same fashion depending upon carbonate, etc., as a normal developer. The masking effect can be lessened by bleaching the silver formed in previous color development steps or increased through the use of non-color forming developing agents to build up to silver deposits. Masking can also be controlled in the respect of the ratio of development of the dye image to that of the silver image through varying the concentration of the color former coupler. The color of the images can be modified by using mixtures of the color formers.

The attempt at the formation of a neutral gray scale by this process has revealed its drawbacks. Usually a compromise has been made for balance at one end of the scale and a passing full-scale balance has been obtained only through extended manipulation and experimentation.

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An Apparatus for Determining the Tensile Strength and Elongation of Single Fibers

By L. B. SHIRES

Dep't of Chemistry and Chemical Engineering, New Mexico College of A. & M. A., State College, N. M.

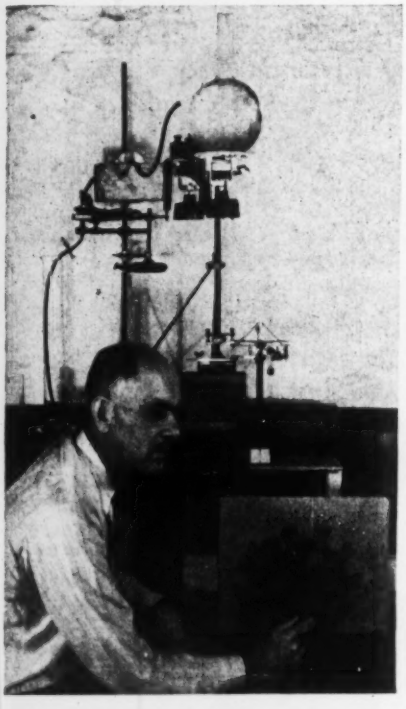
INTRODUCTION

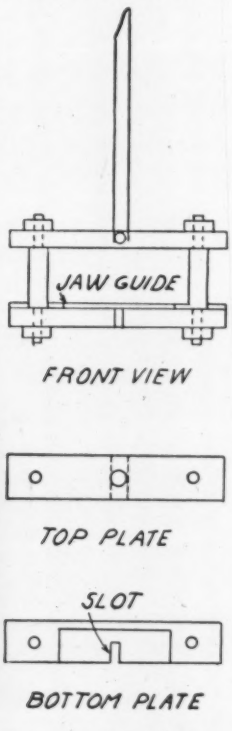
IN 1942 a project was initiated by the New Mexico Agricultural Experiment Station to investigate the possibility of obtaining fiber from desert plants, which might take the place of fibers formerly imported from the Orient. Since the tensile strength of fibers is one of the chief criteria of their usefulness for the manufacture of rope, cordage and related products, it was necessary to devise some method for measuring it. The elongation of a fiber under tension and its percent elongation at the breaking load are also sometimes desirable. By reason of priorities and other limitations, the apparatus was to be made, if possible, from materials already at hand.

DESCRIPTION

A Harvard trip balance of 5-kg. capacity, equipped with a clamp to take a vertical round rod and hooks beneath the pan hangers, was made use of in the construction of the breaking apparatus. The balance is supported on a vertical steel rod about 75 cm. long and of such diameter that the opening in the clamp will barely pass over it; however, it must be loose enough so the balance may be moved along the rod when the setscrew is released. The vertical rod is rigidly attached to a base large enough to give stability: about 40 × 40 cm. is a convenient size. Securely attached to the rod about 50 cm. from the base is a collar from which three rigid supports lead to the outer edges of the base, one from each side and one from the rear. It is necessary that the rod, for a few centimeters above the collar, be strong enough to support a load of about 10 kg. without bending. The balance is then clamped to the rod a couple of centimeters above the collar by means of the clamp.

A light steel rod 30 cm. long and 2 or 3 mm. in diameter with an eye on one end is placed over the hook beneath the pan hanger of the balance. The lower end of the rod carries a receptacle for holding one of the jaws in which the fiber is placed. The receptacle consists of two 5 × 1 cm. brass plates 1.5 cm. apart held together with bolts. The plates of the receptacle must be rigid enough to carry a load of 4 or 5 kg. on their middle sections, without showing any appreciable deflection. The top plate has a hole in its center to take the small steel rod and is secured to it by setscrews from both sides of the plate. The bottom plate has a small slot, midway between the ends and extending about 5 mm. in from the front edge. There is also attached to the bottom plate a sheet of aluminum with a section cut into which the jaw will just fit (Fig. 1).





(Left) The author and the fiber tester. *(Right)* Fig. 1. Diagram of upper jaw receptacle.

Directly beneath the receptacle a block of wood is attached to the base. The top of the block should be about 6 cm. below the receptacle for holding the upper jaw when the pointer of the balance is on zero. Small metal plates are attached to the top in such a manner as to insure that the jaw will always take the same position on the block. Some means for clamping the jaw on the block must be provided; obviously, a number of variations are possible. However, if elongation is to be measured, the jaw must be held rigidly in its position, as any upward movement will be measured as elongation of the fiber.

An L-shaped rocker arm on a shaft is located beneath the balance plate opposite that carrying the small steel rod. When the balance is overloaded, the height of the rocker arm is adjusted so that it receives a kick from the plate of the balance, which closes a glass stopcock through which water flows. The rocker arm shaft and stopcock are best supported by clamping them to a separate steel rod attached to the base.

Each jaw consists of two brass or steel plates 3 cm. long, 1 cm. wide, and 3 mm. thick, the dimensions being relatively unimportant except the width, which should be accurately known. Holes are provided near the ends to take a small bolt, by which they are clamped together. The two jaws are duplicated and the inside faces are covered with leather.

To expedite opening and closing of the jaws and obtaining the proper fiber length, a jig is provided. The jig must maintain a fixed distance between the jaws, in our case 5.0 cm., and provide means of holding the bolt heads while the jaws are being clamped together. Since a number of different arrangements would be equally satisfactory, no details are given.

An aspirator bottle with a capacity of 3 or 4 liters is placed on the pan of the balance which holds the upper jaw receptacle. A flask with a siphon is sometimes more convenient. The aspirator bottle or siphon from the flask is connected to the stopcock with a piece of flexible rubber tubing, so that it will not interfere with the oscillation of the balance. From the other side of the stopcock a short piece of rubber tubing leads to a vessel calibrated in ten-ml. divisions, having a total volume of 3 liters or slightly greater.

The apparatus for measuring the elongation of fibers under tension is a separate unit and is used in connection with the breaking unit only when such measurements are desired. The unit is constructed entirely from apparatus which no longer performed the service it was originally built for. A worm gear was permanently fastened to a base so that the circular gear was parallel to the base. The worm gear was so constructed that ten rotations of the worm cause the circular gear to rotate once. Attached to the center of the circular gear, and a couple of centimeters above it, is a nut having threads with a pitch of 1 mm. A flat-headed bolt is inserted in the nut and guides provided to keep it from rotating with the nut when it turns, thus causing the bolt to move up or down when the nut is turned.

The case is removed from an old discarded analytical balance; the pans, bows, stirrups, and arresting mechanism

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dismantled. The base of the balance is then set over the worm-gear mechanism and fastened in such a position that the bottom of the column on the beam-arrest rests on the center of the flat-headed bolt which is raised and lowered by the nut on the circular gear. The above mechanism is then placed in a position so that when the agate on one end of the beam is placed under the receptacle holding the upper jaw, the pointer can be brought to zero on the index plate by rotating the worm gear. If the circle through which the worm rotates be divided into ten equal divisions, variation of 0.01 mm. may be recorded, since the ratio of the worm gear is 10 to 1.

ADJUSTING

With the aid of the jig a fine wire of the desired length is inserted and clamped in the center of the jaws. The jaws with the wire are then transferred to their receptacles on the breaking unit, the lower one clamped on the block in a position determined by stops, the other inserted in the upper receptacle. Next weights are placed on the balance plate sufficient to make the wire barely taut; the position of the balance on the upright is now adjusted so that the pointer is on zero and the wire in a perpendicular position. This alignment must be fairly accurate if good results are to be obtained. The jaws are then removed and dismantled.

The bottle or flask on the balance together with the train leading to the receiving vessel are filled with water. The train must be free from air bubbles. The top jaw assembled, but empty, is placed in its receptacle and weights placed on the balance plate until the pointer is near zero. It is convenient to have the weights near the center of the two beams on the balance, and make the final adjustment of the pointer at zero by shifting these to the proper position. The apparatus is now ready for operation.

OPERATION

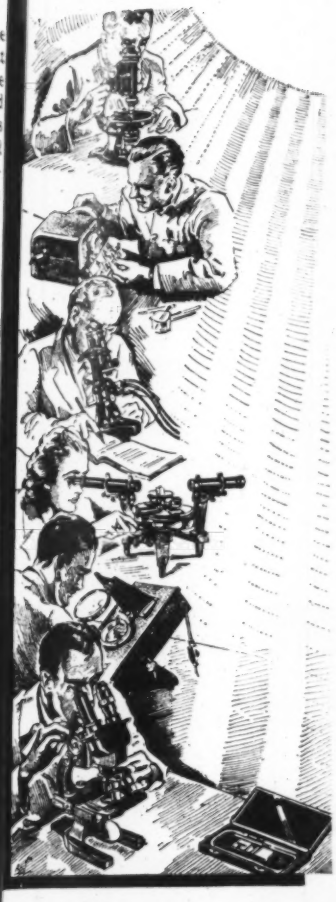
The exact position of the weight on the beam of the balance is noted when the pointer is at zero and the top jaw is in its receptacle. The jaw is then removed and the larger beam weight is moved just enough to cause the water end of the beam to drop. This contributes to the ease of inserting and clamping the jaws in their proper positions, as this causes the fiber to bend and form a bow.

The jaws are placed in the jig and opened; a fiber long enough to extend at least 1 cm. beyond the edge of each jaw is selected and placed approximately in the center of the jaws. The top part of the jaws is then placed in position; the ends of the fiber beyond the jaws grasped by the fingers and gently pulled back and forth until it is in the proper position (middle of jaws). The nuts are then tightened sufficiently on one of the jaws to keep the fiber from slipping when the breaking load is applied. The end of the fiber extending beyond the opposite jaw is grasped by the fingers, gently pulled until it is just taut, and held in this position until the jaw is closed. With a sharp knife the ends of the fiber are cut off flush with the edges of the jaw. The jaws containing the fiber are now transferred to the breaking unit and clamped in their proper position. A little care is required in placing the upper jaw in its receptacle to avoid cutting the fiber on the slot through which it passes. The weight on the beam balance is now moved back to the original place, where the pointer was at zero with the upper jaw in its receptacle.

The stopcock is opened and water flows from the bottle on the balance to the receiving vessel, thus increasing the load on the fiber at nearly a constant rate, until the breaking point is reached. When the fiber breaks, the rocker arm closes the stopcock and the volume of water in ml. which flowed into the receiving vessel is recorded as the load in grams necessary to break the fiber. Since the density of water changes with the temperature, a small error is involved, but it is of little or no importance here.

The jaws containing the broker fiber are then placed in the jig, opened, and the fibers transferred with the aid of forceps to a microbalance and weighed.

If the elongation is to be measured, the same procedure, with one exception, is followed for inserting the fiber into the breaking unit. The weight on the beam of the balance, in place of being moved to its original position, is placed so



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In addition to standard instruments, Spencer has been supplying special instruments, optical systems and optical parts to other manufacturers for use in their products, for industrial research or process control.

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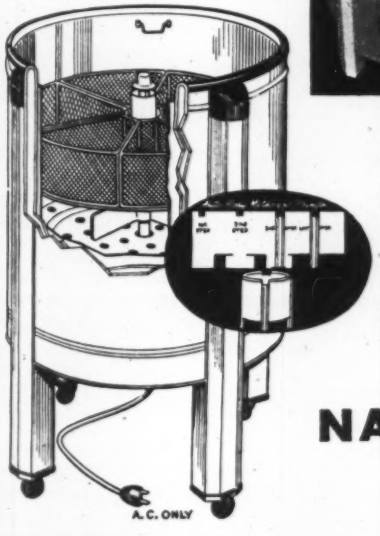

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that an excess load of 5 or 10 g. is obtained. This insures that the fiber is taut; the excess load is then added to the weight of the water in the receiving vessel.

The elongation measuring unit is moved into a position such that the agate on the end of the beam of the analytical balance comes under the bottom edge of the receptacle holding the top jaw. The worm is now rotated until the pointer is at zero. The stopcock is opened, and as the fiber stretches, the worm is slowly turned so as to keep the pointer at zero. The elongation is determined by the number of revolutions made by the worm after the flow of water starts, each complete revolution of the worm equaling 0.1 mm.

RESULTS

As the diameters of the fibers even of the same kind and from the same source vary widely, it is not feasible even to attempt measuring their cross-sectional area. Under such conditions, it is customary to state tensile strength as: the length of the fiber which would cause it to break under its own weight. When so stated, the tensile strength is, of course, independent of the cross-sectional area. The breaking load does vary, however, in some unknown way with the length of the fiber used; thus comparisons of different fibers can be made only when the distance between the jaws is kept accurate.

If the breaking load is recorded in grams, the weight of the fiber in milligrams, and its total length in cm., the following formula will give the length in kilometers which would cause the fiber to break under its own weight:

$$\frac{\text{(Total length in cm.)} \times \text{(Breaking load g.)}}{\text{(Weight in mg.)} \times (100{,}000)} = \text{km.}$$

It is a well-known fact that fibers, even from the same leaf, vary greatly in their tensile strength. Generally speaking, the results obtained from five or six fibers from the same leaf represent the results which are obtained from any leaves of the same species. A typical result of six fibers picked at random from a single leaf of *Yucca baccata* gave the following results for a distance of 5 cm. between the jaws and the total length of fiber 7.0 cm.:

Breaking load, g.	*Weight mg.*	*Tensile strength, km.*	*Percent elongation at breaking load*
2075	1.845	78.6	2.7
1190	1.055	79.0	2.8
720	0.715	70.5	2.5
1495	1.460	71.6	2.6
1865	1.770	73.8	2.8
1350	1.265	74.7	2.6
		av. 74.7	av. 2.7

The above variations are of about the same magnitude as those obtained by other workers, both in this country and abroad, using various types of apparatus.

Aircraft Electrical System Suggestions

By CORWIN SHELBY GREEN

Assistant Instructor Aircraft Electrics, New Mexico State College A. & M. A. National Defense Training School

FOR instruction in maintenance, trouble-shooting and installation of aircraft electrical systems, we have had difficulty in producing a sound and thorough method of "transmitting to the Student" the correct and complete knowledge of location and correction of electrical troubles, etc., due to the lack of actual equipment with which to demonstrate.

The policy of our school is to give the Student classroom knowledge PLUS practical working knowledge of his subject and a basis for his further improvement on the job.

Since we did not have access to aircraft that had any considerable amount of electrical equipment, we decided to

Looking to the future . . .

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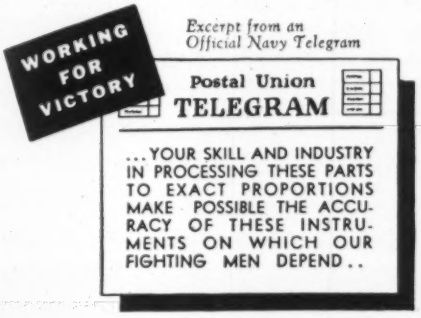
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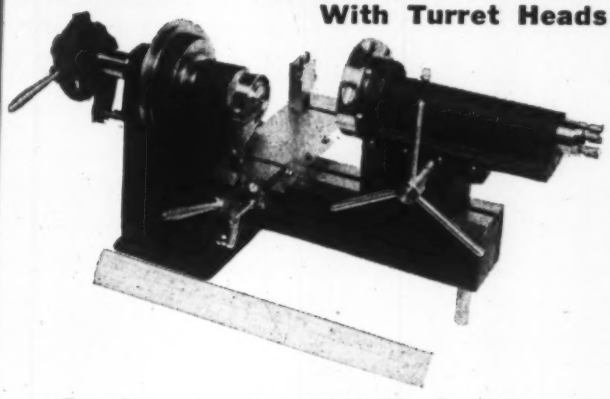

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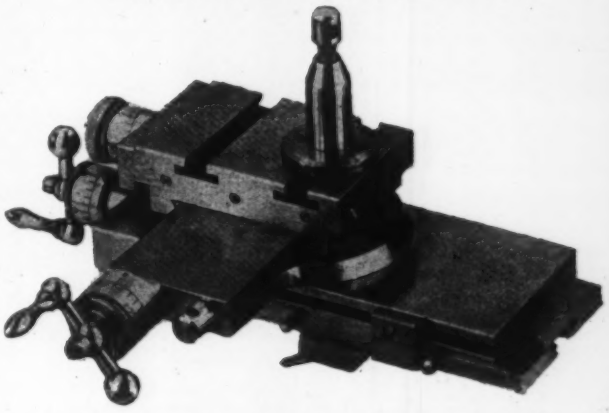

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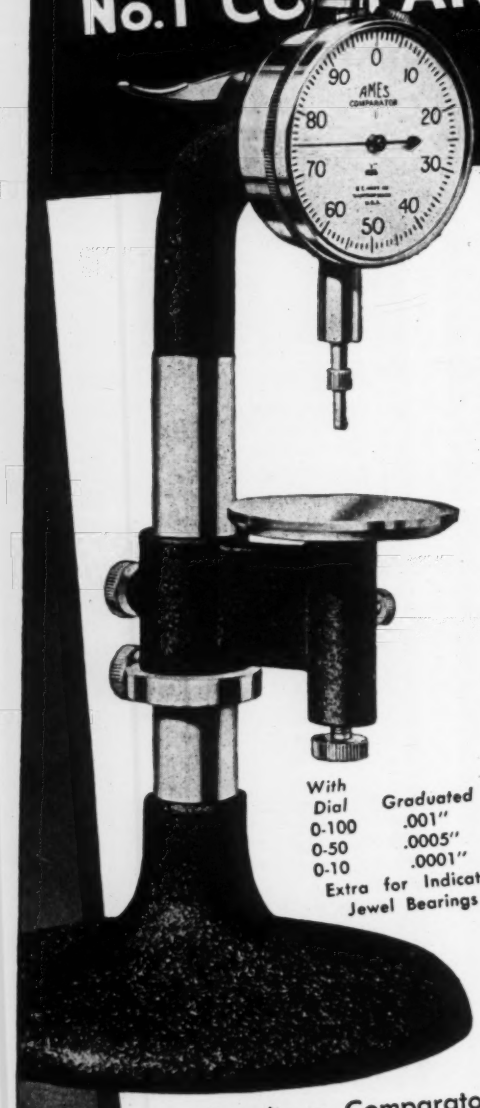

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Other models are shown in catalog No. 54.

Send for a copy.

B. C. AMES CO., WALTHAM, MASS.

construct a working model (mock-up) of an aircraft electrical system, built into a "mock-up plane." This unit is sufficiently large to permit the installation of standard wiring, junction boxes, electric motors, lights and various other electrical accessories.

Fortunately, we were allowed to "pick through" an aircraft salvage dump and, to our surprise, we found numerous crash units (crash salvage discards) such as wiring assemblies, disconnect plugs or cannon plugs, junction boxes, release latches, solenoids, relays, clips, various motors, lights, etc. With this material, the Student learns repair and installation, the repaired units being installed on the mock-up.

After installation, the instructor takes over and puts as many "kinks" as possible into the electrical system and then puts the Students to the job of tracing down and correcting the faults. This method, I believe, gives the Student a practical and thorough understanding of the trade he intends to master, covering heavy-duty equipment such as generator circuits and starters as well as the smaller indicator motors, etc.

As a specific example, the mock-up contains a standard aircraft generator, driven by an electric motor which actually charges a storage battery. This is equipped with a standard voltage and rate-of-charge regulator. Of course, the Student learns in the classroom the details of operation of these units, but on the job on this particular set-up, he learns, the normal charging rate is 7 amps. at 14 volts, which requires a clearance of 0.064" on the regulator points, a certain tension on the regulator spring, etc.

The complete procedure for testing, overhauling, reconditioning, installation and adjustment is performed by the Student; thereby he acquires the knowledge and experience which is difficult without such a plan as outlined.

Elementary Data on Fluorescence

By Private MAHLON V. KIRK

A.S.T.U. #3858, State College, New Mexico
(Formerly with the California Science Institute)

FLUORESCENCE is a phenomenon that has recently come into general notice. Its first really widespread application was in the illumination of the San Francisco and New York world's fairs in 1939 and 1940. The growing use of fluorescent tubular lamps during the past four or five years has served, also, to bring this phenomenon to the notice of the general public.

References to fluorescence occur as far back as 1570. However, it was not until 1852, when Sir G. G. Stokes made an investigation of this phenomenon, that its true nature was realized. Stokes called it "Fluorescence" after the mineral fluor-spar which exhibits this phenomenon to a marked degree.

Fluorescence is the changing of invisible (ultraviolet) radiation to visible light. For example, in the tubular fluorescent lamps used for general illumination, an electric arc is produced between the end terminals in an atmosphere of mercury; the resulting mercury radiation is extremely rich in ultraviolet frequencies and it causes the powder coating inside the tube to glow brilliantly.

Stated in another way, fluorescence is the emission of light by a substance when exposed to an exciting radiation of the proper wave-length. The relation between the wave-length of the exciting radiation and that of the emitted radiation is expressed in Stokes' Law, which states that the emitted radiations are of longer wave-length than that of the exciting radiation. In general, most substances follow Stokes' Law. Fig. 1 shows a portion of the spectrum of electromagnetic radiations and brings out the regions of interest in connection with the study of fluorescence.

In order to understand fluorescence more fully it is nec-

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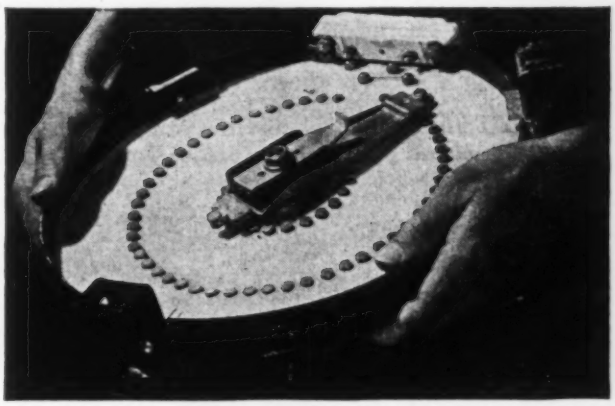

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essary to understand something of the structure of atoms. An atom consists of a nucleus around which planetary electrons revolve in definite orbits. Each electron is held in its respective orbit by a force similar to gravitation. An orbit is not a geometrical circle but it may be called an energy level. When additional energy is applied, some electrons may change temporarily from one energy level to a higher energy level. A photon of radiant energy is emitted by the atom when an electron returns to its original level. This

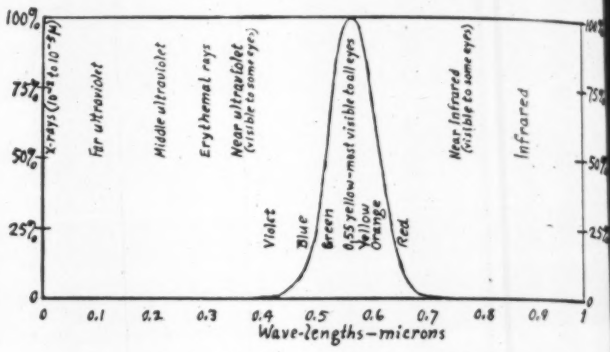


Fig. 1. Visibility curve of the human eye

liberated energy may become evident as visible radiation. If an electron has been pulled to a higher energy level and the exciting radiation is removed, two effects may result: The electron may move instantaneously to its original level. In this case the phenomenon is known as fluorescence. If, however, the electrons do not all return immediately to their original orbits with the cessation of the exciting radiation—if they return "one by one," so to speak, in minutes or hours, giving off their characteristic radiation, the phenomenon is called phosphorescence. The wave-lengths of these emitted radiations are in some cases dependent upon the temperature of the material. At lower temperatures some electrons may be "held fast" or "slowed down," and the others whose characteristic radiation may be of a different wave-length will then become apparent. Some materials will not phosphoresce at normal temperatures, but on cooling to the temperature of liquid air will have a definite phosphorescence. Also, as in the case of fluorescin, an organic dye (Fig. 2), a new band may be found for the fluo-

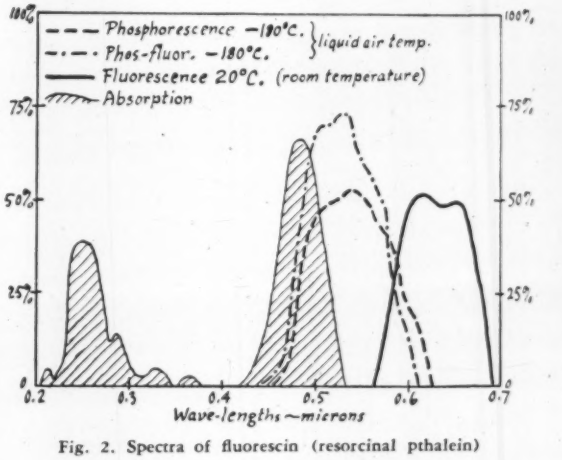
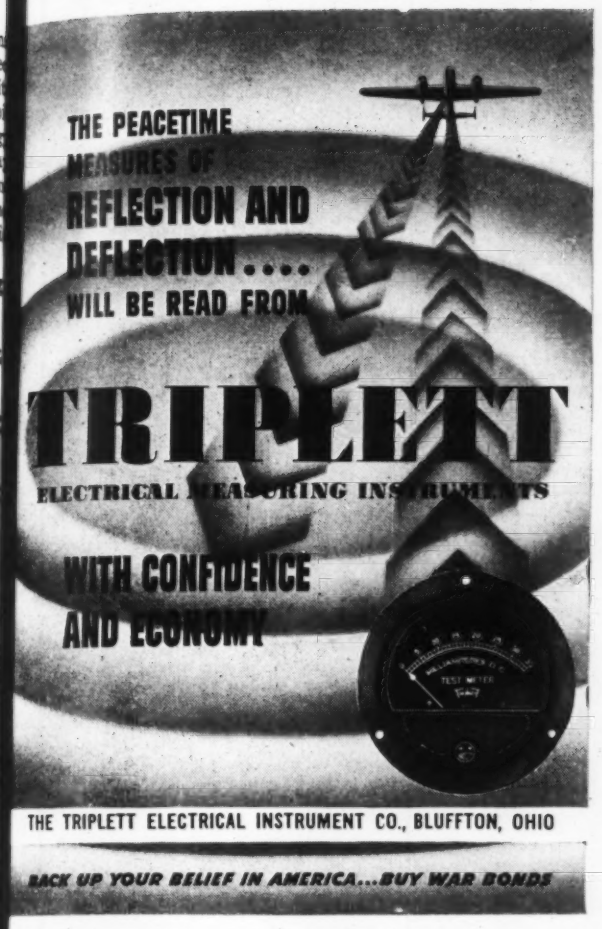


Fig. 2. Spectra of fluorescin (resorcinal pthalein)

rescence. [Phosphorescence and fluorescence are two of the phenomena of *luminescence*, which is light-emission not directly attributable to incandescence.]

Fluorescence has long been used in X-ray work. The fluoroscope, as its name suggests, is an instrument that makes use of fluorescence in X-ray observations. A screen of certain zinc silicates and calcium tungstate, when exposed to the X-radiation, will glow brilliantly with visible light.

Today, fluorescence is used widely in the field of enter-



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tainment. Many stage productions use luminescent make- and stage props for special effects. Many movie houses ha fluorescent carpets which, in addition to being decorati enable the patrons to make their way to and from th seats with much ease in the dark. Many theaters, rest- rants, etc., have installed spectacular fluorescent murals.

The wartime need of our industries for high-speed tun sten steels and for tungsten to be used in the manufactu

TABLE I

Mineral	*Argon bulb*	*Mercury vapor Lamp*	*Quartz Tube*
Agate		blue-white	blue-white, yellow
Aragonite	red to yellow	red to yellow	red to yellow
Autunite	green	green	green
Barite	orange	orange	orange ; white
Calcite		red-orange	red
Chalcedony		yellowish white	blue-white
Diamond			red ; blue
Fluorite	blue	blue	blue ; green
Opal	green	green ; white	green ; white
Scheelite			blue ; golden yello
Wernerite	golden yellow	golden yellow	golden yellow
Willemite	green	green	green
Wollastonite		greenish yellow	greenish-yellow

of electrodes for use in electronic apparatus has caused great number of people to take up "black light" or ultra violet prospecting. The mineral scheelite ($CaWO_4$), one the principal ores of tungsten, is a highly fluorescent ma terial, glowing with a brilliant blue-white light. The "blac light" prospector works at night, methodically going bac and forth over a likely area, illuminating the outcrops wit the dim, bluish glow of a portable ultraviolet lamp. Occa sionally one of these prospectors will be rewarded by th brilliant blue or golden glow of the fluorescent sheelit Many other minerals also are brilliantly fluorescent an some of them are prized by mineral collectors. A small de posit of some commercially unimportant mineral may pa big dividends to the lucky finder, for mineral collectors wi pay good prices for good fluorescent and phosphorescen mineral specimens.

Table I gives a list of some common fluorescent minerals the type of lamp required to activate them and their color of fluorescence. Any one who can provide himself with th proper type of ultraviolet lamp can derive endless enjoy ment from hunting for and experimenting with these fluo

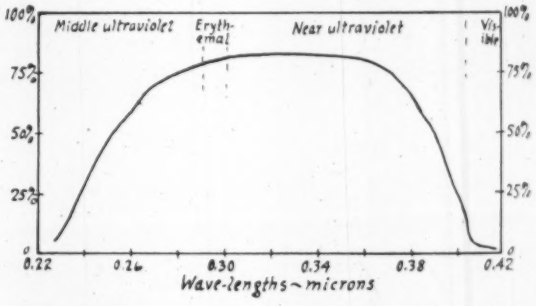
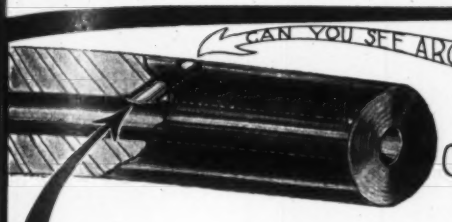


Fig. 3. Transmission of typical filter glass used with ultraviolet lamps for tungsten ore prospecting.

rescent minerals. The simplest and cheapest ultraviolet light source is the argon glow lamp which may be purchased for about a half dollar from any electric supply house. It works on either a.c. or d.c. at any voltage from 60 volts to 220 volts. For those who wish a more elaborate and more versatile piece of equipment there are a number of bulbs on the market, the commonest type consisting of a quartz-enclosed mercury arc enclosed in a high-transmission clear glass bulb or a built-on filter glass envelope. These bulbs must, of course, be operated by a special power supply. For tungsten prospecting there are several factors limiting the choice of apparatus. The unit must be portable, with a self-contained power supply. It must have a light source that



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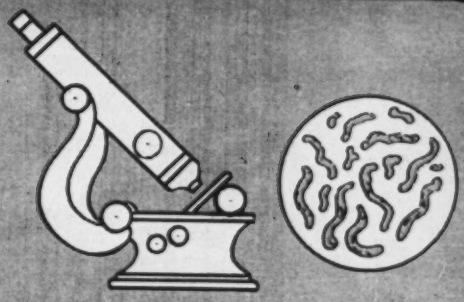

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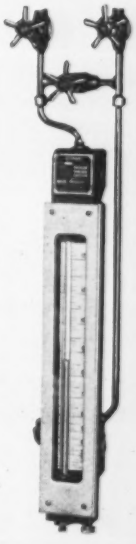

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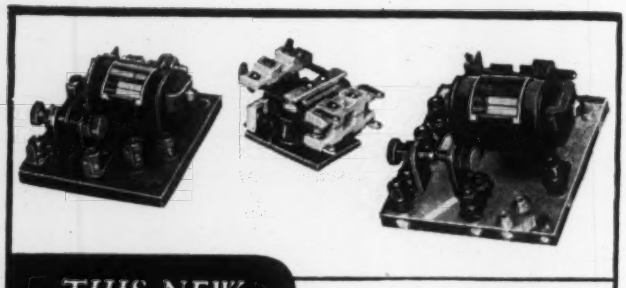

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radiates in the erythemal and middle ultraviolet regions of the spectrum, as the tungsten minerals will not fluoresce to any other portion of the ultraviolet. This last is accomplished by using one of the so-called cold quartz tubes and a filter having a transmission curve similar to the one in Fig. 3. There are excellent portable lamps now on the market that satisfy all of these conditions admirably.

In the field of aircraft instrument dial and pointer illumination, fluorescent materials have made possible great improvements, many of which are secret, as are uses of fluorescent and phosphorescent materials in tanks and submarines.

The study of fluorescence is a large field, the surface of which has only barely been touched. Many untried applications of fluorescence will probably present themselves soon. At some future date it may be possible to make a complete quantitative and qualitive analysis solely by observation of the fluorescence and phosphorescence of the material being tested. Fluorescence is probably the answer to the need for soft well-distributed interior illumination. We may look forward to the complete application of fluorescent paints on the ceilings and walls of our homes as the sole illumination. The softly glowing fluorescent paints, illuminated by concealed ultraviolet lamps, will furnish even, glareless light and will add tremendously to the beauty of our homes.

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AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

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The following articles have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

The Guild Q&A Column

Conducted by F. H. HONEYCUTT, Guild Recorder

Q. In setting up a gyroscope rotor in the balancing fixture, I hear a loose sound, but the rotor indicates too tight on start test. What is the cause of this? (M. M., Texas)

A. The most logical answer to this condition is the rotor pivot has too long a taper—it is ground on less than the required 40 degrees, giving you a loose or bubbly sound, even though it will be tight on a start and coast test. If more than 40 degrees you will have a long coast and high start. Remember the taper on all pivots must be 40 degrees. Deviating from this will also create difficulty in getting the proper number of swings on the vertical or gimbal rings.

Q. When a case leak of the Rate of Climb Indicator is evident, why will the pointer sometimes fail to rotate past the zero setting when the suction is stopped?

A. This discrepancy is caused by too much suction. Just enough suction is needed to cause the pointer to indicate 500 feet per minute. Due to the inherent lag (6 to 9 seconds), if the pointer displacement is too great, the differential pressure in the case and diaphragm will have had time to equalize before the pointer returns to zero. Actually, when this suction is cut off, the greater pressure is shifted from the diaphragm to the case, causing a down indica-

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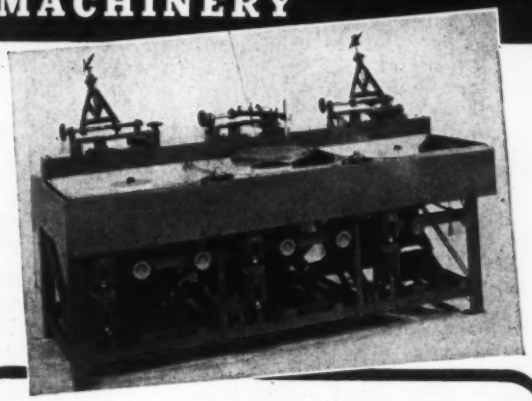

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. . . in a two-month period

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This means that these precision timers are rugged as well as extremely accurate. They were continually started, stopped and reset manually at least 40,000 times a day, 280,000 times a week, or 2,250,000 times during the two months . . . a pretty severe strain on any instrument.

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MODEL S-1 PRECISION TIMER: Specifications: *Speed:* 1 RPS. Totalizes: 60 seconds. *Dial Diameters:* 3 3/16". *Start and Stop Control:* Manual switch and 3 ft. cord standard equipment. *Reset:* Manual, by knob in front of case. *Voltage:* 115 AC motor is standard. *Case:* Molded bakelite, 4½" square. Information on prices and optional equipment on request.

ADDRESS 1-10

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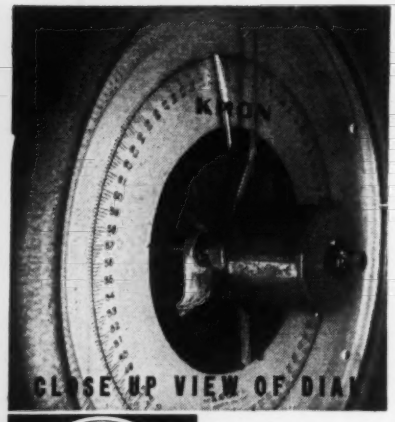

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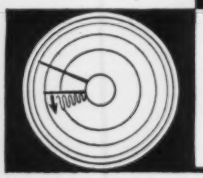
"Magna-Pointer" held at zero before timing interval.

"Magna-Pointer" engages and moves with weigh pointer during interval.



"Magna-Pointer" instantly stalls at end of timed interval.

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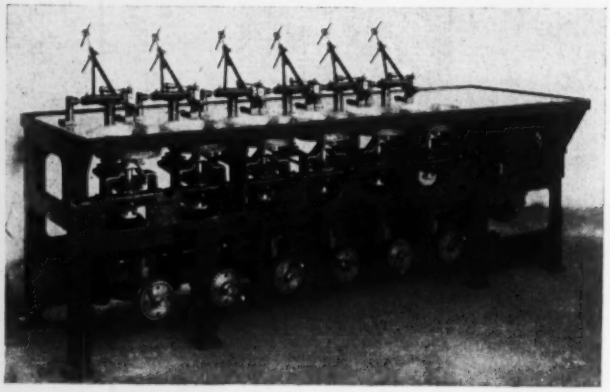

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tion before the pressures in the case and diaphragm are equalized by the leaks. This is true if the suction is not greater than 500 feet per minute.

Q. How do you check for pointer oscillation in the Rate of Climb Indicator?

A. Actually there is no test or check for pointer oscillation in the Rate of Climb Indicator, but through the lag test we accomplish the same desired results when the inherent lag ranges from 6 to 9 seconds, and under turbulent atmospheric conditions, pointer oscillation will be evident. The following tests are for the types C-2 and A-7 using a Rate of Climb calibrating jig with sources of suction and pressure.

Lag test for the C-2 type: Apply sufficient suction to cause an indication of a rate of ascent of 2500 feet per minute and allow the pointer to return to zero position. Then release this suction by opening the static connection to the atmosphere, causing the indicator to show a rate of descent of approximately 2000 feet per minute. With the use of a stopwatch, find the time required for the change from 2000 to 200 feet per minute. This time should be between the seven-second minimum and the ten-second maximum. If the indicator does not meet these tolerances, further calibration of dampening valve or a replacement is necessary. Repeat this procedure, applying a pressure instead of a suction.

For the A-7 type indicator, substitute 1800 feet per minute in place of the 2500 on the C-2, and time the change from 1500 to 200 feet per minute, using tolerance of 6 and 9 seconds.

Notes on Overhaul of Gyro Rotors

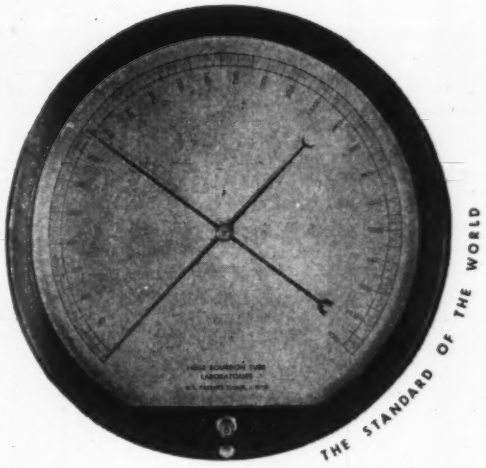
By GERALD E. McEWEN

THERE are a few fundamental principles that one should follow in the overhaul of gyro rotors. No chain is stronger than its weakest link. Likewise no gyro is any more durable or lasting than its rotor. The rotor is the heart of the instrument and from this spinning mass we get the operation of our instrument. The fundamental principles of operation of a gyroscope, rigidity and precession, depend upon a spinning mass. The more rpm's a rotor turns up, the more rigidity we are going to get. In order to get a rotor that will hold up at terrific speed, we have to be much more precise in our procedure. Friction must be held to a minimum. We must keep striving for perfection and have a burning desire within us to not be satisfied with "good enough," but to make each and every job better than the

Gerald E. McEwen received his early training at the Shelby School of Aeronautics, Memphis, Tenn., and in three years has worked up to Instrument Department Ass't Foreman, Brookly Field, Mobile, Ala. The first of this year he was loaned to the M.O.A.S.C. Post School as an instructor of gyro instrument overhaul—maintenance, installation, ground check, flight check and testing.

Mr. McEwen explained in his letter to me transmitting this article, that there is nothing in the article that is news to an experienced gyro man, but he realizes (as must everybody) that the chief purpose of the Aircraft Instrument Guild is for experienced mechanics to help the newer members of our trade to advance in experience faster, both for the sake of the War Effort and for the operator. They in turn can be beneficial to us.

Let's have more of these articles from more of you. We've had requests for various methods of calibrating Directional Gyros and Artificial Horizons. Can some of you calibrators come to our help? —R. G. OJERS, Guild President



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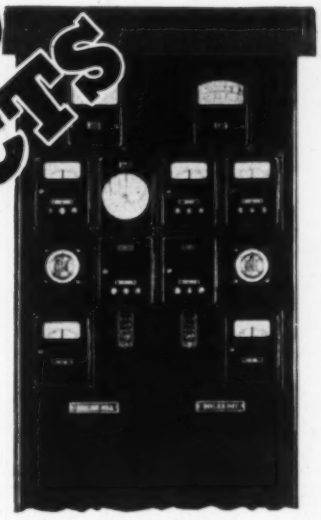

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last one. To be able to do this we must know something about rotors and their make-up. Also something about the things to guard against and the things we must do. To begin with, we must have perfect or as nearly perfect pivots, balls, and races, as it is possible to get. If they are not, then it's up to us to make them perfect. I don't think that anyone has ever got just what he would call a perfect job, but if we keep working in that direction, our instrument will reward us for our extra pains. In this article I won't go into the methods of repair, as most methods are in a way each individual's personal opinion. Of course there are technical order specifications in the Army that we have to adhere to, so anyone working for the Army or Navy will know the overhaul procedures they must follow. Care of parts is often the means of success. Always place in a small bottle of oil all pivots, races, balls, and any metal part that is likely to rust. Never let any part stay overnight in a bottle of cleansing solution such as benzine, petrol ether, gasoline, etc., as pivots and the like will rust badly within a few hours and oftentimes in minutes, due to the moisture content. In assembly, be sure that all parts are perfectly clean. You can't be too particular in this respect. In using air pressure to blow off the lint from your cleansing paper left on the pivot, race, balls, etc., be sure to use low-pressure filtered air. This is necessary, as air coming from an air hose at high pressure will be cooler than the air of the surrounding atmosphere and will cause dew to form; the humidity of the air will condense and will cling to your metal part. Even though you do place this part in oil, it will still rust, as the oxygen in this moisture will allow the pivot to rust. After all, we know rust is the oxidation of your metal. Be sure that the pivot is clean when you place it in the oil. This also applies to any metal part that you are trying to keep clean and free from rust.

Be sure than all balls are perfect that you are going to use in a bearing assembly. Never mix balls of different bottles together. Each bottle has balls that are perfectly matched to 0.00001" at the factory. If you have to replace a damaged ball in a race, replace all new balls unless the set of balls you have are new balls taken from a certain bottle, so that you can get another ball from this same bottle for replacement. Just because the balls you are using are all new balls, never take for granted that they are all good balls, for often you will find brand-new balls that have flat spots, pits, and other damaged places in them. You must remember that it is hard to get the quality steel to make these balls as in the past. Now the manufacturers have to use whatever steel that they can find available. This also holds true for pivots, races, etc. Inspect each part thoroughly and be critical in your inspection, so as to be sure that each part is going to work. In stoning your pivots you absolutely must maintain the 40-degree angle of the pivot. In lapping the pivot this angle has to be maintained. Lap only the ball track, or "ball path" as some call it. This part of the pivot is all that you are interested in. This ball track is the working part and it has to be perfect—no pits, scratches, comets, flat spots, or anything that would cause friction or cause excessive noise. If you try to lap all the pivots, it will make a beautiful shiny job, pretty to look at, but you have lost the angle of your pivots because you have removed too much metal and have produced a dished-out condition. In dishing out this pivot you will have not only ruined your pivot for use without reworking it, but you will have worn out a good lap for yourself. Boxwood is next to impossible to get, so help preserve your supply. A correct lapping job has only the ball track lapped and the metal isn't as much removed as it is smoothed over or burnished down.

In disassembly of bearing assemblies, such as turn rotor bearings or top flight rotor bearing, you will notice four little springs under the bearing that fit in little wells in the housing cap. Never mix up these springs, as they are all from a matched set that have a certain tension and are all placed with shims under them so that the bearing assembly will set level on these springs, thereby giving even tension of the bearing on all these springs. If the bearing doesn't set level on these springs, the tension will be uneven and a

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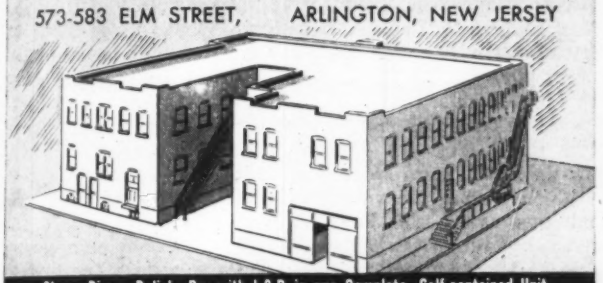

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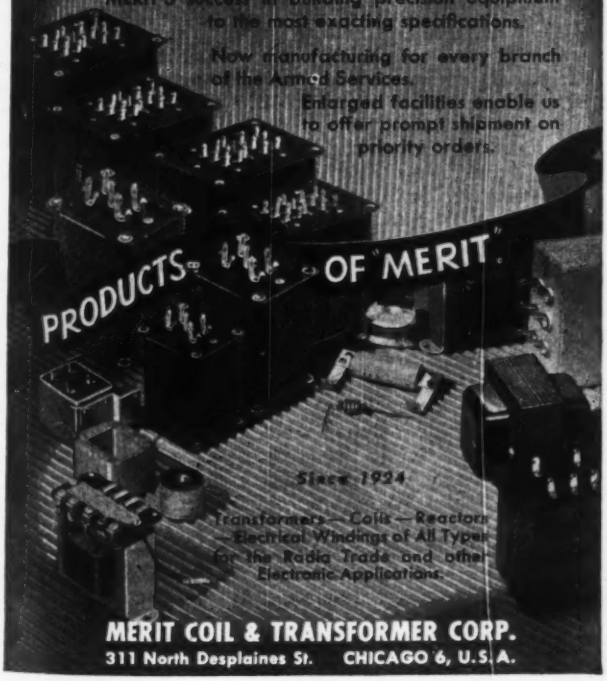

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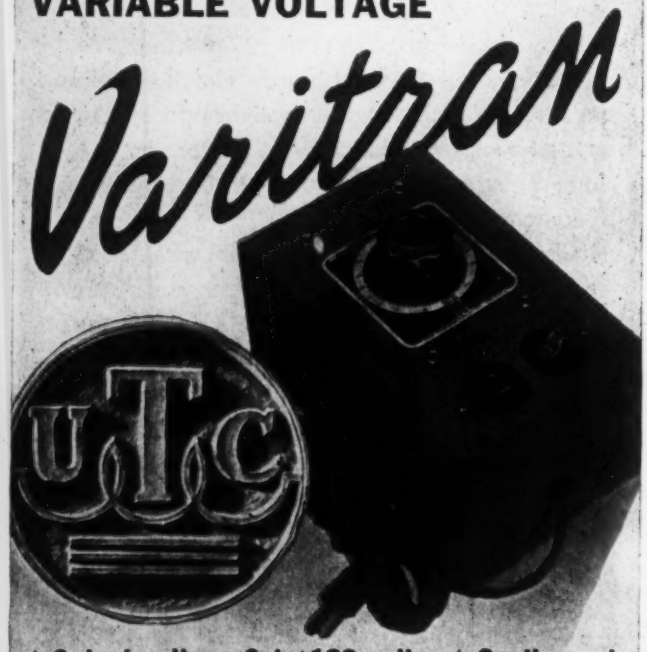

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cocked bearing will be the result. This condition will give you a ball drop that can't be taken out without having too much tension of the ball on the pivot. The balls will be traveling around the pivot at an angle instead of straight around the pivot in the ball path. A cocked race tends to create surge. To remove the ball drop, the rotor will be so tight that you can't get more than approximately a six-minute coast. A rotor must be able to come to a free, easy stop with a slight backlash. If rotor comes to an abrupt stop with an oscillation, it is certainly too tight. If your rotor will coast between eight and ten minutes and have a good sound, then you can rest assured that your rotor will hold up all right in final calibration, unless something unforseen turns up. I have found through experience that if the condition of the assembly is such that it will come to a free, easy stop with a slight backlash and start anywhere from 0.2" to 0.5" Hg., it will coast almost the right amount of time without any more adjustment. However, if you do have to make an adjustment, then only a very slight adjustment is necessary.

So far we haven't said anything about the dynamic balance of the rotor. If a rotor isn't dynamically balanced it is no sign that your instrument will not calibrate, but it is a sign that your instrument will not hold up in service.

An unbalanced rotor will give your pivots and bearings such a beating that at the first sign of dirt or anything that will cause friction and heat, the friction will be amplified to such proportions that it will cause the rotor to burn out very soon. Not only will the damage to the rotor show quickly, but the instrument as a whole will have more wear in all its parts, from the excessive vibration set-up. This will show up in the gyro horizon or flight instrument to excess in the pendulum assembly. In a few hours running, the pendulous vanes will have oblong holes worn where the shafts go through the pendulum body. These holes, wearing worse as time goes along, will soon necessitate the instrument being sent back for repair. Then a complete rebushing job will have to be done and time and expense of the instrument piles up.

This condition must not be tolerated by any mechanic. He must be sure that his rotor is in perfect shape, both mechanically and dynamically as is possible. The rotor shaft must be gaged every time any metal has been removed by stoning, etc., so that the center of gravity within the rotor will not be changed. Every time the pivot has had anything done to it in a rotor, the rotor must be checked for dynamic balance. In flight rotors or gyro horizon rotors, in the lower bearing assembly you will sometimes find a weight-shifting effect. This is caused by the bearing not being tight enough in the bearing recess. A test that will determine if the bearing is tight enough is to take a scriber or any sharp tool and place it against the retainer snap ring and press it around. If the race turns, the bearing is too loose in the recess. If the snap ring turns and the race remains firm, the bearing is tight enough. All bearings must be tight in their respective recesses in order to prevent weight shift in the instrument. It is impossible to calibrate an instrument that has weight shift in any of its various assemblies. In a flight or gyro horizon rotor assembly this weight shift will cause the rotor to loosen up, sometimes beyond the maximum tolerance set up for coast test. Weight shift in a turn or directional gyro rotor assembly is generally caused by lack of tension of the springs under the race. This condition can be remedied by placing shims under each spring, and being certain that the springs are all level, thereby increasing the tension of the springs.

Let's consider the various sounds of a rotor. We say that to judge a good rotor it must sound right. But what is a right kind of sound? Nearly every gyro mechanic you talk to has a different explanation. The reason for that is: all sounds that we use as a comparison to other sounds are some that we have had previous experience with. It is impossible to tell you just how noisy is a noisy rotor just the same as it would be impossible to tell you just how high is up. However, most mechanics agree that a good rotor must have a smooth swishing sound. There will be no ball drop. A ball drop has a metallic clink to its sound. When you have

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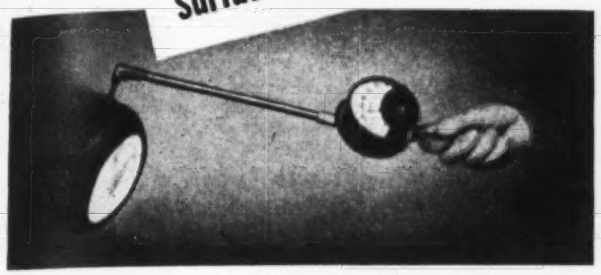

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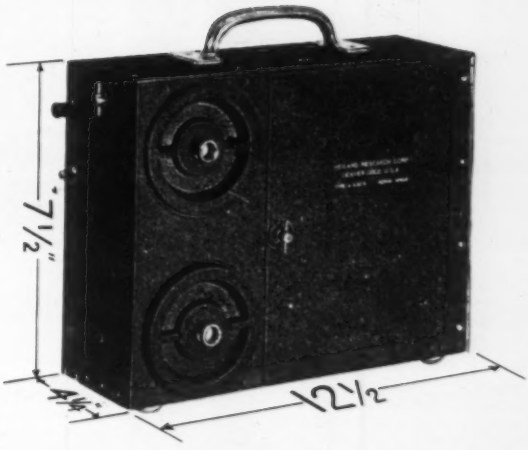

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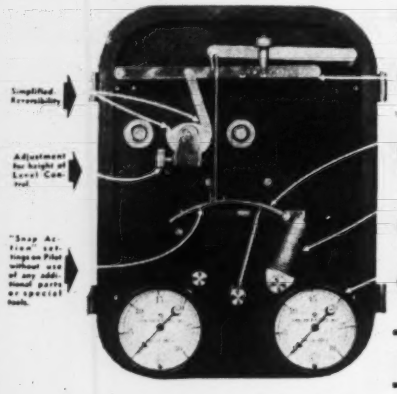

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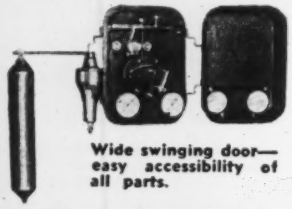

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H-B THERMOMETERS

just the edge of a ball drop, you can say that you have a squeaking sound such as tin foil makes when you bend it, or very much the same sound as wheels turning in snow. A pit in a rotor pivot has an even, solid, purring noise very much the same as an outboard motor. A flat ball is similar but not nearly as fast, the sound gradually increasing to its loudest point, then decreasing to nothing. This cycle repeats itself. A pit in the race is similar, but as to speed, its frequency is slower. You have three different frequencies of pit noises to master. The highest speed frequency of pit noise can be termed on the rotor pivot. The medium speed frequency can be termed as pit in the race. The lowest speed frequency can be termed as pit noise on one of the balls. A flat spot on a pivot will sound similar to a pit on the pivot, but inspection under the microscope will determine which one it is. Comets, scratches that are not concentric around the pivot, will also give you the effect of having a pit. Concentric lines in a race will not harm the pivot or bother the coast test to any extent, as long as they are the same depth and are concentric. They will smooth out in running. Now as to the noise that we call a beat or surge in a rotor, it is hard to establish just what is the exact cause of this. We know there are several things that are contributing factors to this condition. You might ask what I mean by a beat or surge in a rotor. The nearest definition that I might give is that you have a condition set up where you have unsynchronized frequencies existing. The rotor, running at high speed, will "wow-wow" or have a surge. In my opinion one of the things that causes this is an off-angle pivot, causing the balls to run up out of the ball track and form a new ball track in a different path, and setting up different frequencies. Too, different inside diameters of the races set up different frequencies. Dirt in the bearings on one side, producing friction on that side, sets up different frequencies. A pitted ball or oval ball sets up different frequencies. These are just a few of the main causes for having this beat. In lapping a race excessively you are taking out metal, thereby changing the inside diameter. In stoning a pivot it is very easy to get off angle if you are not careful. The point of the pivot will cut faster than the heel of the pivot, thereby changing the angle. In lapping you can change the angle of the pivot by lapping too much and dishing out the pivot. If the metal in a race is not homogeneous, it will not have exactly the same amount of temper throughout and will grind in some spots faster than in others, thus setting up a wavy condition inside the race. This condition cannot be seen with the naked eye or under microscopic inspection, as the race may look perfectly good and yet be so wavy as to set up a beat in your rotor, creating an error sufficient to render the race unfit for use. Beats in a rotor, if excessive, will set up a vibration or shimmy in a rotor assembly, thereby transmitting this shimmy to the entire instrument and causing excessive wear. In centralizing a rotor in a gimbal ring of a turn indicator, I've found it just as easy to centralize the rotor to within .0005 of an inch as it is .001 inch. In doing this we are helping to keep to a minimum all errors that might be involved in the dial indicator or fixture or male plug used in the end of the gimbal. Often it may be necessary to make an indication from both the 90-degree and the 270-degree side of the gimbal and divide the difference in the readings to get an absolute correct centralization. If the gimbal is sprung ever so slightly, you will be unable to recognize this error, but it will show up in calibration. The rotor will have an out-of-centralized effect and this spinning mass outside the vertical axis of the instrument will set up an effect that will cause cross readings in your instrument. In dividing this error by indicating both sides of the gimbal, you will show an out-of-tolerance indication on each side maybe, but this tolerance will be plus on the one end and minus on the other end, so that the center of gravity of the rotor will be in line with the vertical axis of the instrument and the rotor will have a centralized effect.

I do sincerely hope that this little insight of rotors will help someone that may have been having trouble along these lines. It may make clearer some of the things that have been such a puzzle.

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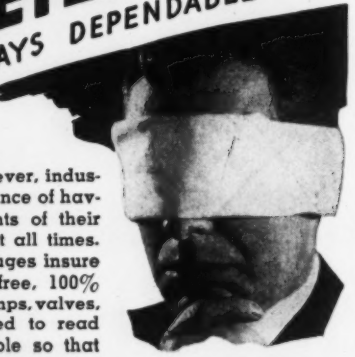

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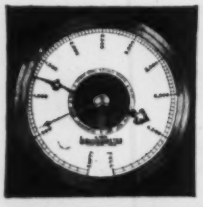

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Controller Adjustments

Concluded from page 596

again and readjust the sensitivity. It is doubly important to keep records on "proportional plus reset" controllers. Each time one is adjusted, jot down the sensitivity and period of oscillation. You are through adjusting the instrument when the sensitivity is at the lowest value found and the reset rate is less than the reciprocal of the longest period in minutes.

A few notes on period determination may be in order. On recorder-controllers, the period can generally be measured on the time axis of the chart; but short periods are more easily timed with a stop watch or by counting seconds. [Timing is always necessary on indicating controllers since there is no record. Watch the pointer's oscillations and take the time from the peak of a swing until the next peak in the same direction.]

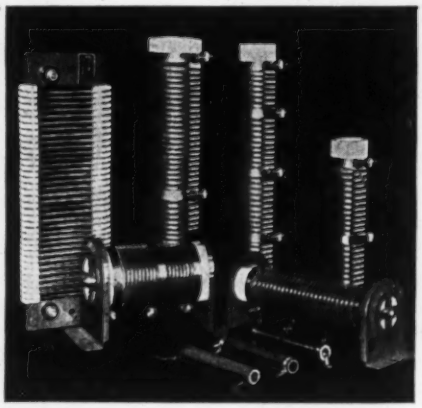
Don't be misled by false periods. Friction in a control circuit, usually valve friction, can introduce a fairly regular "wander," easily mistaken for an oscillation. This effect usually disappears if the sensitivity is increased until an amplitude ratio near 1.0 results. If a wander is suspected, lower the sensitivity considerably; the amplitude of the wander will increase. A positioner on the valve will generally eliminate wander.

Electron Tubes

Concluded from page 604

Gas-filled, or "gaseous," tubes as they are known, have become an extremely important part of the electron tube family. In less than fifteen years their use has been extended from the simple battery-charging application to almost every branch of industry and electrical engineering. In the conversion of alternating current to direct and in the "inversion" of d.c. into a.c., they have become indispensable.

In performing the comparatively simple function of rectification they have made possible many interesting and useful industrial devices. Consider the one shown in Fig. 41 for example. This circuit is used in the operation of the "Syntron" electric hammer for drilling holes in concrete at high speed and for similar purposes. Currents in two solenoids alternately and periodically act on a common steel core to pull it to and fro in synchronism with the alternating current in the line. "Tungar" or "Rectigon" rectifiers are employed to change the alternating current into pulsating current. When the voltage pulse is negative on the right hand side of the circuit, the electron current flows through tube 1 and coil *A* and the steel core or plunger hammer is pulled in that direction to compress a spring. On the reverse voltage swing, the electron current flows through coil *B* and the plunger hammer is pulled in that direction as it is simultaneously pushed by the spring, thus causing it to strike a sharp blow—60 times a second on a 60-cycle circuit.



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To the Editor of *Instruments:*

In Chapter IV of Mr. Andrew W. Kramer's timely articles on "Electron Tubes," there is a historical mistake which I would like to correct.

On page 415, Mr. Kramer says "It (the Fleming Valve) was the best detector of wireless signals that had been developed up to that time." That is not so. The preferred detector, prior to the Triode of DeForest, was the Dunwoody Carborundum Detector (U. S. Patent 837616), which was used almost exclusively in the Marconi Transatlantic Service and on radio-equipped ships, and was undoubtedly the best.

Further, Mr. Kramer says that "in the course of his work (DeForest) made use of the "Fleming Valve," which is hardly correct. The so-called Fleming Valve was the valve of Elster and Geitel, on an application of which Edison obtained patent 307031 in 1883. Moreover, the British patent 24850 issued on the Fleming Valve in 1904 was bad, and—looking to its possible extension—its assignees sought to amend it by disclaimer when it was about to expire, but were unsuccessful. (The inventor had claimed too much.) It is true that DeForest might have experimented with a so-called Fleming Valve, but since there was available to him all the work of Elster and Geitel, and Edison—about which Fleming had often lectured before he applied for his patent—there was no reason, other than his convenience, for his doing so; and when he "merely introduced a third electrode into the tube" he contributed a very great deal to the art.

All this is a matter of record in my book "Radio: Beam & Broadcast," now out of print.

ARTHUR H. MORSE

Elmhurst, N. Y.,
July 29, 1943

To the Editor of *Instruments:*

Mr. Morse's comment on my statements concerning the use of the Fleming Valve as a detector raises a question that would provoke animated discussion among the old timers in radio even at this late day. All of us who were in "wireless" in those days can remember the pet detectors and methods of using them that each one had. As to which detector was the "best" prior to DeForest's triode, this is largely a matter of opinion and when I referred to the Fleming valve as being the best I probably was voicing my own opinion. Properly operated, it had a degree of stability, theoretically at least, that few other detectors had. As Mr. Morse points out, the Dunwoody Carborundum Detector was used widely and it was a good detector but so were many others and each had its own proponents. Pickard's "perikon" detector for example was the favorite of many. While Marconi used the carborundum detector in transatlantic service, he also used others, notably his own magnetic detector. When the Fleming valve was developed the Marconi Co. used that, apparently with good success. Quoting from the first edition of Zenneck's "Wireless Telegraphy" published in 1915: ". . . in the more recent form of Fleming's oscillation valve the anode being a cylinder of carbon and the cathode a tungsten wire, this detector seems to have met all reasonable requirements as to sensitivity and reliability. This is borne out by the fact that Marconi has been using it in conjunction with an Einthoven galvanometer in his transatlantic service."

As to whether DeForest actually used a Fleming valve in his early experiments or a tube based on the work of Elster and Geitel, this is a question which Mr. DeForest can best answer himself. When I referred to DeForest's use of the Fleming valve, I implied the use of a diode of the type used by Fleming. The DeForest audion, as first constructed, was in the main identical with the Fleming construction except that DeForest made use of an auxiliary battery and potentiometer in the plate circuit of his receiver. Later, as I pointed out, he introduced a third electrode into the tube which subsequently developed into the grid.

This introduction of a third electrode into the tube, as Mr. Morse indicates, was a great contribution to the art and I had no intention of minimizing its importance in my use of the word "merely." By "merely" I meant that the practical transformation of the diode into the triode was very simple.

ANDREW W. KRAMER.

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Instrument Societies

BALTIMORE

The first annual business meeting of the B. I. I. S. was held at the Maryland Academy of Sciences on September 17. The annual reports of all standing committees were presented and approved. I believe we have had a very successful first year, especially when all of the problems brought on by the war are considered. Our average attendance at the meetings was between thirty-five and forty. The officers for 1943-44 are as follows:

President, F. B. Bevelheimer; Vice President, B. M. Dewey; Secretary, C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.; Treasurer, F. G. Ragan. FRED PULLEN

CHICAGO

The first meeting of the fall season of the Chicago Society for Measurement & Control was held on September 13th at the Windemere West Hotel. An exceptionally large audience greeted the speaker of the evening, Mr. Wilbur Pray of the Askania Regulator Co., whose subject was Combustion Control.

While Mr. Pray touched on the theory of combustion control, he devoted considerable time to tracing the history of the development of combustion control. His talk was interspersed with humorous anecdotes of his own personal experiences which further enhanced the enjoyment provided by his presentation. —J. A. RIGGS

NEWARK

The first fall meeting of the Society for Measurement and Control (New Jersey) opened auspiciously with a banner attendance of 81. The interest and enthusiasm exhibited plainly illustrated the tremendous importance of Industrial Instrumentation in our War Production Efforts and augurs well for automatic control in our Post War Industrial Economy.

The speaker of the evening was Coleman B. Moore, Senior partner of Moore Products Co. of Philadelphia. He delivered an illustrated lecture on "The Pneumatic Null Balance System Applied to Industrial Instruments." Mr. Moore traced the development of the Null Balance System from the simple "One to One Pressure Transmitter with Direct Nozzle System" through the various pneumatic circuits, illustrating the Amplifying Transmitter, High Range Amplifying Pressure Transmitter, Differential Pressure and Liquid Level Transmitter, Valve Positioner, Temperature Transmitter, and finally a system of automatic control mechanisms utilizing the same underlying principles employed in the measuring equipments. He described the application of the controller to Industrial Control Processes, explaining the value and use of throttling and automatic reset, and rate response units. A lively discussion was participated in by a goodly number of the members present.

The newly elected officers and committee chairmen are as follows: Harry F. Moore, President; L. M. Hackenberg, Vice President; N. E. Chance, Acting Secretary; M. J. Seavey, Treasurer; *Committee chairmen:* L. M. Hackenberg, Program; R. F. Roberts, Housing; E. Englehardt, Membership; N. E. Chance, Publicity; R. J. Crane, Nominating.

—N. E. CHANCE

> This is YOUR page, society members. See that your Secretary or Publicity Chairman uses part of it. M. F. BEHAR, *Editor*

NORTHERN INDIANA

The September meeting was held on the 17th at the Lake Hotel, Gary, Ind. Mr. H. C. Frost, field engineer from the Leeds & Northrup Co., gave a very interesting talk on "Fundamentals of Automatic Control" which was enjoyed by all.

—R. W. SCHREINER

PHILADELPHIA

Addressing the September meeting on "Continuous Temperature Measurement with Electronic Potentiometers," Walter Wills of the Brown Instrument Co. covered thoroughly the three fundamental functions of the system, such as the conversion of a. c. to d. c. voltage, the amplification of the signal voltage, and the balancing motor operation. This portion of the talk was illustrated with blackboard diagrams.

Various curves were screened up on an oscillograph operating in conjunction with demonstration instruments. This brought home to the novice a clearer picture of the happenings.

Mr. Wills' explanation of the operation of the system left the group stumped for a moment at the start of the discussion period, and then they followed with some right lively questions which were skillfully answered.

The meeting attendance was 82, with 27 at the dinner.

Members, don't forget to submit your general instrumentation questions for the November "Question and Answer Nite."

—GEORGE HAMMER

INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control					
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Nov. 19(D)	Maryland Academy of Sciences	To be announced	
			Dec. 17(D)	Maryland Academy of Sciences	Rayotube Pyrometry	H. L. Pfaffhausen, Leeds & Northrup Co.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Nov. 1(B)	Windermere West Hotel, 1642 E. 56	Aircraft Engine Testing Instrumentation	To be announced later
			Dec. 6(B)	Windermere West Hotel, 1642 E. 56	Instrument Maintenance in an Oil Refinery	B. A. Hiermeier, Sales Mgr., Brown Inst. Co.
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.	Nov. 9(B)	Essex House	Application of controllers to industrial processes	W. B. Heinz, Cons. Engr. Cochrane Corp.
			Dec. 4(B)	Essex House	"Information Please"	Panel of "Experts" from our members
New York	New York Society for Measurement & Control	R. K. Farnham, 545 Fifth Ave., N. Y. C.	Oct. 26(B)	Churchill's Terminal Restaurant	Hydraulic Approach to Measurement & Control	Ed S. Smith, Research Engr. Eclipse-Pioneer
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Ill.				
Philadelphia	Philadelphia Society for Instrumentation	George Hammer, 712 Otis Bldg., Phila. Pa.	Oct. 20(B)	Engineers Club	Pneumatic Null Balance System & Applications	C. B. Moore, Pres. Moore Products Co.
			Nov. 17(B)	Engineers Club	Instrumentation Questions and Answers	Quiz Board to be announced
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Oct. 25(B)	Roosevelt Hotel	Instruments in the Australian Army	Oswald F. Mingay, Australian Ministry of Munitions
			Nov. 22		Oxygen Instruments	Wm. Wildhack, Natl. Bureau of Standards
			Dec. 27		The Rotameter and its Secrets	Kermit Fischer, Pres. Fischer & Porter
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co.				
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C)Dinner at 7, meeting at 8. (D)Meeting at 2, no dinner.

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Quite by accident, three DuMont Type 164E 3-inch oscillographs were submerged in salt water. Duly recovered, they were returned for salvage—repair, if at all possible; otherwise, replacement.

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While we do not recommend dunking as a regular thing, we submit this case as still another proof of the ruggedness of Dumont equipment. It is certainly reassuring when you face extra-severe service conditions. Likewise indicative of years of trouble-free life.

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G-3

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The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Industrial Thermometers

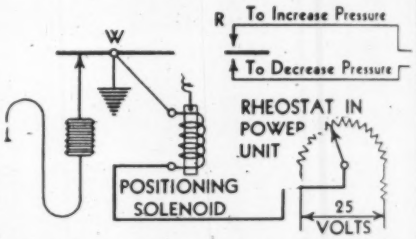
New series of Industrial Thermometers with a plastic case front, yellow-back easy-reading thermometer tubing and malleable iron back is announced. By using a plastic case front, weight is reduced and an adequate substitute for metal is provided. New plastic case front is not affected by the temperatures to which the case is subjected under actual service conditions. Either the glass or the entire front can be replaced at nominal cost. Yellow-back lens-front thermometer tubing is said to be a great improvement over the white-back type since yellow background offers best color contrast with mercury. Moreover, new tubing is comparatively easy to produce and it involves no complicated construction of bore or lens. Malleable iron has been found to be an entirely satisfactory substitute metal for the brass formerly used, and is fully protected against corrosion by a durable black finish.—*C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*

Heavy-duty Capacitors

Announcement is made of a new line of heavy-duty high-voltage capacitors for continuous operation up to 150,000 volts working. Pictured 0.5 mfd. unit is a 50,000 volt d-c. capacitor: it is 28" high, weighs 175 lbs. and is constructed for 24-hour continuous operation and total submersion in salt water. New units can be used in surge and lightning generators, are equipped with maker's solder seal terminals for operation at highest altitudes and under the most humid conditions encountered.—*Industrial Condenser Corp., 1725 W. North Ave., Chicago, Ill.*

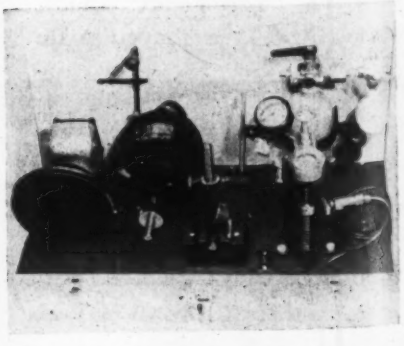
Pressure Switch for Proportional or Automatic-reset Control

New "Micro Pressure Switch" is primarily a simple and conventional three-wire pressure switch, but with the addition of a solenoid under command of the valve-operating power unit which is itself under command of the switch. This "feedback" or "automatic-reset" or "droop correction" principle permits the combination of this new switch and of a suitable power unit to be used as a fully automatic pressure control system of the continuous-proportioning type. (Maker's power unit was described in *Instruments*, July 1942, page 273.) Diagram shows how voltage-dividing rheostat in power unit, keyed to power-unit driving shaft, varies voltage to pressure-switch solenoid and thereby varies pull on switch armature, until new balance is established with oil-burner valve (or other final element) in new position. Applications include control of steam boilers, automatically fired by proportioning type oil burners, gas burners, and stokers; suction pressure of multiple Freon compressors and regulation of head pressures in liquid-level control.—*Barber-Coleman Co., Rockford, Ill.*



Spark Plug Tester

New "Model P 80" portable spark plug tester is a self-contained testing unit consisting of a hand- and motor-driven magneto, hand-operated pressure test bomb and a gap setting tool, designed to service BG spark plugs and Aero, Bendix, Champion and AC plugs of the aircraft type. The 110-



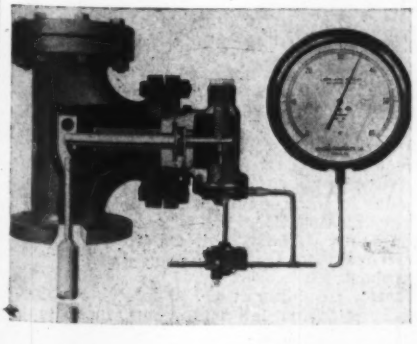
volt ⅛-h.p. motor, used for driving the magneto when a-c. power is available, also has an arbor and collets for cleaning spark plugs. Supplementing hand pump pressure test bomb, a small detachable bottle of carbon dioxide makes possible testing of more than 1,000 plugs without refilling. Equipment mounted in a metal box weighs approx. 80 lbs., is said to be ideal for mobile field repair units and can be easily transported in trucks, planes, boats and tanks. A variety of gages, adapters and wrenches and an electrode forming and adjusting tool complete the set.—*Airplane Mfg. & Supply Corp., 6853 Lankershim Blvd., North Hollywood, Calif.*

Outdoor Photoelectric Relay

New "Type CR7505-K108" general-purpose photoelectric relay for outdoor use is for applications requiring rapid and accurate counting, controlling, sorting, or limiting operations. Its contacts control 2 amps. at 115 volts, 25- to 60-cycles, a.c., or 0.5 amp. at 115 volts, d.c. In addition to a Type GL-930 phototube, new relay contains a Type GE-117P7GT pliotron tube. This amplifier tube is said to be outstanding in two respects: its filament operates on full line voltage, obviating need for a filament transformer; and it incorporates a diode rectifier which functions when a-c. power supply is used. Weatherproof case is equipped with a sun shield and a large directional lens system to minimize effect of slanting sun rays. In addition, lens system increases relay's sensitivity. Relay can be mounted in any position and can be adjusted under actual operating conditions, without removing cover. Chassis can be removed from case for inspection or servicing or, if desired, for mounting with other apparatus in a combination enclosure.—*Electronic Control Section, General Electric Co., Schenectady, N. Y.*

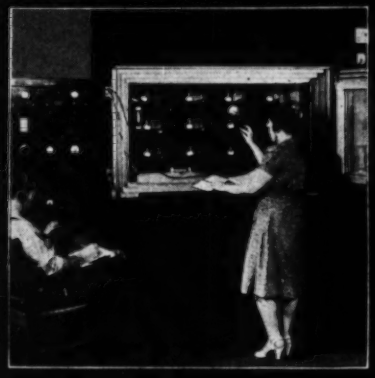
Long-distance Liquid-level Gage

New "Nullmatic" liquid-level gage operates on maker's pneumatic null balance principle (see *Instruments*, April 1942, page 148). Equipment consists of a transmitter with Moore Booster Pilot Valve, and a receiver which may be indicating, recording or controlling, for installation at a distant point. Transmitter may be furnished with

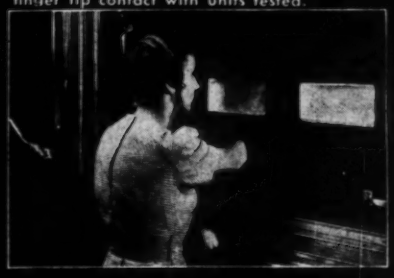


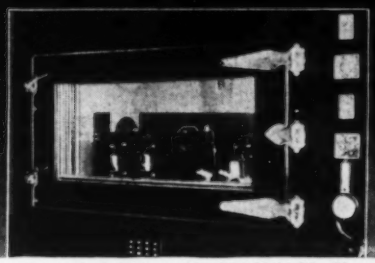
FINDING COLD FACTS ABOUT WAR-NEEDED INSTRUMENTS

LOT TESTING of frequency meters at the plant of Allen D. Cardwell Mfg. Corp., Brooklyn, N. Y. Note the panel of twelve meters. This method permits temperature testing of a large number of meters at one time. During testing at sub-zero temperatures, operators work in comfort at room temperature.



HER FINGER TIPS HAVE AN ICY TOUCH. Plunging her arm into a protective sleeve, this operator makes hand adjustments on radio parts being tested in this AMCOIL humidity and temperature test chamber. As used at the Cardwell plant, this way of making adjustments has proved its advantage over shaft tests, because of direct finger tip contact with units tested.





HOW'S YOUR ARCTIC BEHAVIOR? That question is answered in advance as far as these condensers, transformers and other instruments are concerned. The effects of cold and sudden drops in temperature can be observed during test through the hermetically sealed multiple panes of glass, in this AMCOIL RTC-1XX Testing Chamber.

THESE TESTS HELP THEM. Members of the U. S. Army Signal Corps will use instruments which pass the tests shown in the foregoing series of photographs. Such equipment is vital to keeping communication channels open. Radio parts as well as troops must be seasoned.

The Amcoil Testing Chambers used at the Allen D. Cardwell Mfg. Corp. are regular models containing special testing accessories developed by that company's engineers working closely with Amcoil technical men. The temperature range of these chambers is from −56.7° C. (−70° F.) to +70° C. (+160° F.). Inside dimensions of chamber—52 in. long, 30 in. deep, 27.5 in. high.

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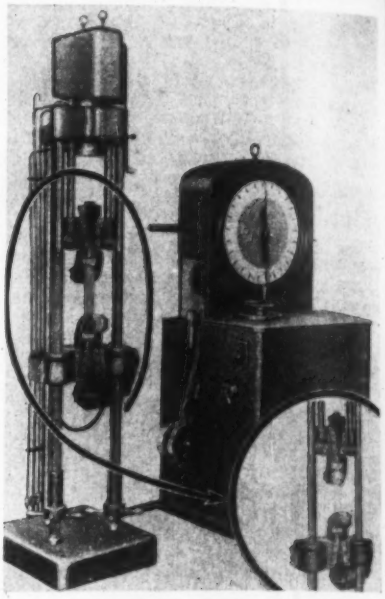
floats over 60 ft. long, for installation on pressure tanks or on large tanks of spherical construction. Transmitters are also available mounted in float chambers, for the control of liquid level. Equipment is said to be especially well applied on hazardous or corrosive fluids, by reason of packless construction and ability to confine any leakage of hazardous fluids inside safety pressure housing containing balance mechanism. Construction is suitable for working pressures as high as 300 lbs./in.^{2}. *Operation:* Transmitter utilizes principle of force change due to buoyancy of liquid rather than a float following a changing level. A stainless steel disk carrying the float arm is mounted on outlet of tee. Tubular float is suspended from one end of float arm and balance bellows is connected to other end. A small change of buoyant force on float is balanced immediately by a change of air pressure in bellows. This pressure is transmitted to receiver. By reason of pneumatic null balance principle employed, all members are maintained in equilibrium. Change in balance position on bellows between zero and full scale is less than 0.001", thereby nullifying all nozzle and bellows non-linear characteristics, as well as preventing metal fatigue. This guarantees accurately transmitted pressure, linear with change of level. Stops are provided to keep motion of disk well within its elastic limit. Thrust pivots are provided for overload pressures. Stainless steel packless disk will distort but not rupture on pressures up to 5000 lbs./in.^{2}. *Speed:* With a transmission line of 300 ft. of ¼" O.D. copper tubing, instrument pointer will move from zero to full scale in 3 to 4 seconds. *Special advantage:* Transmitters for use on sub-zero temperatures have balancing mechanism removed from the frosting zone and are compensated for ambient temperature changes.—*Moore Products Co., H & Lycoming Sts., Philadelphia 24, Penna.*

Parachute Web Testing Machine

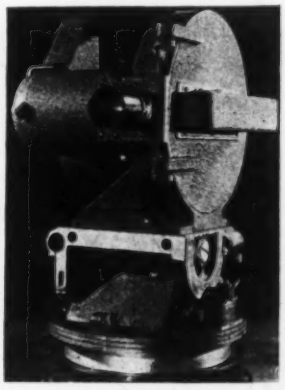
For testing strength and resilience of webbing in parachutes, new precision hydraulic testing machine is said to be characterized by extreme accuracy, reliability



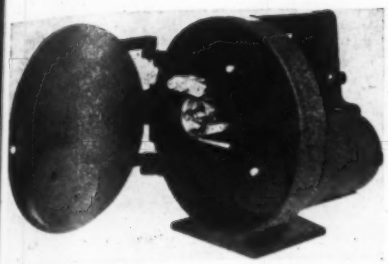
and rapidity of testing. Tester is foolproof; all breaking loads are measured by gravity stress acting on the pendulum. This assures continued accuracy, it is said, for there are no parts of the weighing mechanism which are subject to changed characteristics due to metal fatigue. New tester has a maximum loading capacity of 10,000 lbs., indicates load tests as low as 50 lbs. Special type web grips enable quick, easy attachment to ends of samples up to 3" wide. Maximum testing speeds up to 12" per minute enable the making of 60 tests per hour.—*Riehle Testing Machine Div., American Machine and Metals, Inc., East Moline, Illinois.*

High-speed (8000 frames/sec.) Motion-picture Camera

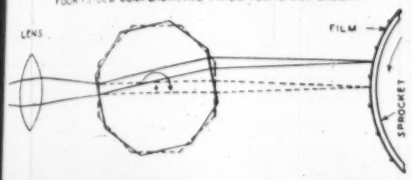
New "Fastax" employs 8mm. and 16mm. film driven at speeds up to 70 miles per hour or 8000 "frames" per second. It employs continuous film drive, as distinguished

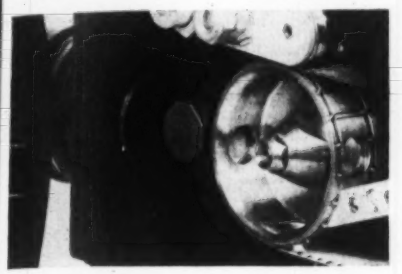


from the stop-expose-advance cycle of professional and amateur slow-motion cameras. Exposure of successive "frames" is accomplished by a revolving prism acting as an optical compensator (see diagram) whereby images travel in synchronism with film past film gate during exposure period. Object under study is illuminated by continuous concentrated light of high-intensity lamp filaments, not by intermittently flashing gaseous discharge lamps as in the use of stroboscopic cameras. This enables the Fastax to photograph self-luminous objects such as fusing lamp filaments, or to make



EIGHT-SIDED COMPENSATING PRISM FOR 8-MM. CAMERA
FOUR-SIDED COMPENSATING PRISM FOR 16-MM. CAMERA





high-speed analyses of polarized light. Wide choice of light sources permits use of many film types including color film up to 1,000 frames per second. The Fastax was originally designed by and for Bell Telephone Laboratories but is announced as commercially available.—*Western Electric Co., 195 Broadway, New York City 7, N. Y.*

Complete Electrical Source Unit for Spectrography

New Multisource Unit for spectrographic analysis combines functions of conventional d-c. arc, a-c. arc, and high-voltage condensed spark units, and provides precisely-controlled excitation suitable for all types of analysis. With it, the three factors of an electrical circuit, resistance, inductance and capacitance, may be set to selected values over wide ranges. Either arc-like or spark-like spectra, with all variations in between, may be had. Moreover, fine control of dis-

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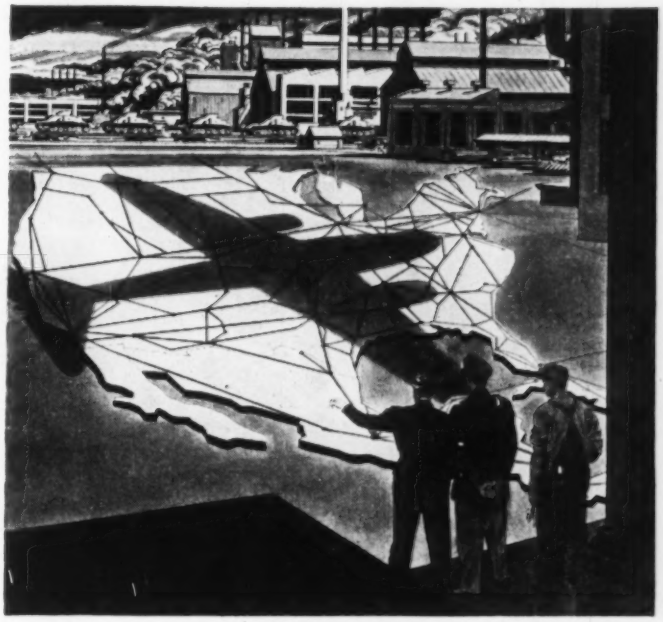

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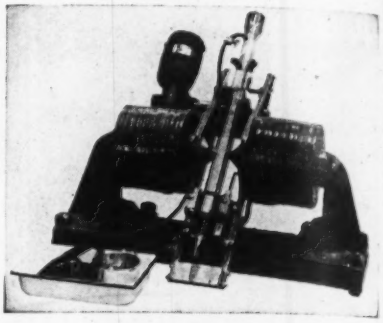
charge afforded by adjustable *R*, *L* and *C* is said to mean that Multisource excitation combines sensitivity of arc with accuracy of spark. Unit comprises a main control panel at front, and a selector panel at side. Selector panel is equipped with pull knobs which allow selection of conditions of discharge. Seven knobs at front of capacitor section allow selection of capacitance values from 1μfd to 60μfd; ten knobs for selection of resistance values from 1 to 400 ohms; five knobs on the inductance section for 25 to 400 microhenries. Switching is all done behind panels by means of heavy well-insulated knife switches. Main panel has an oscillograph whereby current, duration and waveform of an average individual discharge can be studied (as a means of predicting properties of a particular discharge; and for adjusting phase of charging cycle with respect to that of discharge). An ammeter checks power consumption of unit and a voltmeter checks voltage across capacitors before discharge. Another voltmeter indicates difference between input voltage and regulated voltage. A phase control knob, coupled directly to the synchronous gap, provides necessary adjustment of ignition point of discharge. An adjustable 0 to 2-min. synchronous timer controls total time of operation. All necessary switches for starting and adjusting the unit are also provided on front panel. In general, unit "has been designed as the ultimate in source units." Every part has been selected with a "large" safety factor. Resistors are, wherever possible, constructed of low temperature coefficient alloys and heat generated by them is removed from unit with a double blower. Spot-welded housing, 63" high, 28" wide, 50" deep, is subdivided into a series of sub-assemblies, each of which can be inspected and serviced by pulling out a panel. Casters allow the unit to be moved with ease.—*Applied Research Labs, Glendale, Calif.*, and *Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

Magnetic Ore Content Determination Apparatus

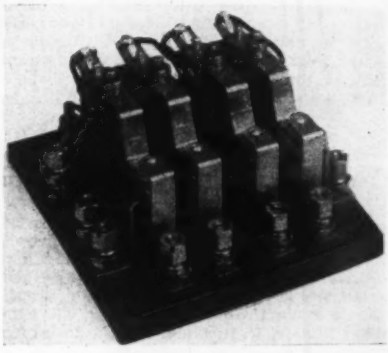
Designated as the "Dings-Davis Tube Tester" or "Tube Type Magnetic Separator," new instrument is said to make possible an accurate, rapid, laboratory determination



of the magnetic content of an iron ore, or of the magnetic metal content of any substance. A thoroughly reliable analysis is said to be obtainable in 10 to 15 minutes.—*Dings Magnetic Separator Co., 509 E. Smith St., Milwaukee 7, Wis.*

Aircraft Relay

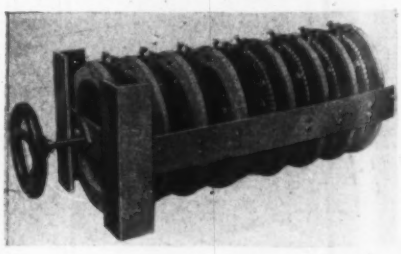
New "Bantam" highly-specialized relay is said to be exceptionally powerful and sensitive. Its weight is said to be "exceptionally light." It comes in one- to six-pole



construction and is available in standard front-connected, screw terminal, solder lug, eyelet, or switchboard mounting. Coil and shading pole assembly are in one unit, replaceable without special tools. If desired, "Bantam" can be supplied with special "tropical treatment" to hold up under any humidity conditions. Horseshoe type magnetic circuit said to be low loss, high permeability material, rugged and durable. No pull-in due to butt joints in magnetic iron structure.—*Kurman Electric Co., Dept. AE, Long Island City 1, N. Y.*

Tandem Rheostat Assemblies

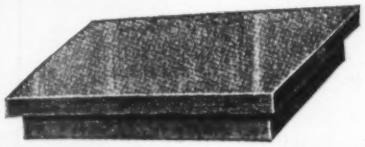
New tandem unit illustrated consists of eight of maker's "Model U" 1000-watt 12" diam. rheostats mounted in a steel frame, is controlled by a single handwheel, is one of the largest units of this type ever assembled. It is unusual, in that eight of maker's largest size rheostats are utilized, but



other tandem assemblies can be made up of two, three or more rheostats ranging in power rating from 25 watts to 1000 watts and in diameter from 1-9/16" to 12". Rheostats in tandem are insulated from each other so that they may be used for simultaneous control of several circuits or phases of a circuit by means of one knob. Two rheostats can be separately controlled by means of concentrically located knobs. This may be done to conserve panel space or where it may be desired to use one rheostat as a vernier for another. In this type of unit two rheostats are mounted in tandem with the shaft of the rear unit extending through the hollow shaft of the front unit. For increased capacity, the front or back units can consist of several rheostats connected together. Tandem rheostats are also available in taper windings and the same range of resistance values as individual units.—*Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Illinois.*

Granite Surface Plates

New type of precision surface plate, for inspection, toolroom, and production departments, is made of certain types of natural granite, recently found to be ideally suita-



ble. These plates do not rust, corrode or warp. They are finished to 1/10,000 of an inch overall with 100% bearing surface. They do not swedge or become charged with abrasive materials. Harder than any tool used on these surfaces, they are said to be practically indestructible under normal conditions.— *The Herman Stone Co., 1238 Leonhard St. at B. & O. R. R., Dayton, Ohio.*

Boiler Meter

New Boiler Meter is said to have been subjected to exacting field tests before announcement. It is a steam-flow-air-flow measuring instrument consisting of an elec-

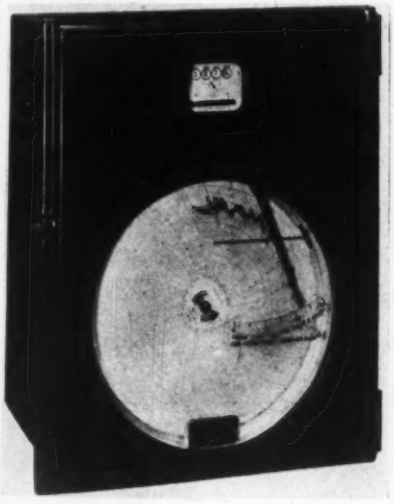


Fig. 1

tric recording and integrating steam flow element combined with an oil-sealed bell type recording air flow meter. The two recordings, made on a 12" chart simultaneously, show steam flow from boiler and rate of air flow to furnace for combustion. Regardless of load carried by the boiler, when furnace is receiving proper amount of air for maximum combustion efficiency, the air flow pen recording in blue coincidentally with the red steam flow pen, gives the

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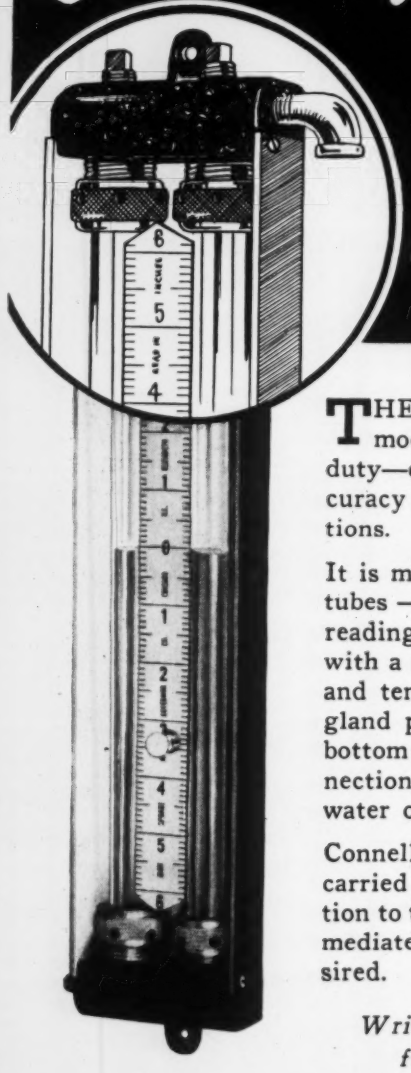

THE New Connelly Manometer, model 3400—built for extra heavy duty—can be depended upon for accuracy and long life under all conditions.

It is made with large bore, clear glass tubes — ¾" in diameter — for easier reading even at a distance. Supplied with a scale graduated either in inches and tenths or in metric measure. It is gland packed, with drain plugs at the bottom and is fitted for ⅛" pipe connections. Made for use with either water or special anti-freeze solution.

Connelly Model 3400 Manometers are carried in stock in five sizes. In addition to these stock sizes, larger or intermediate sizes can be supplied if desired.

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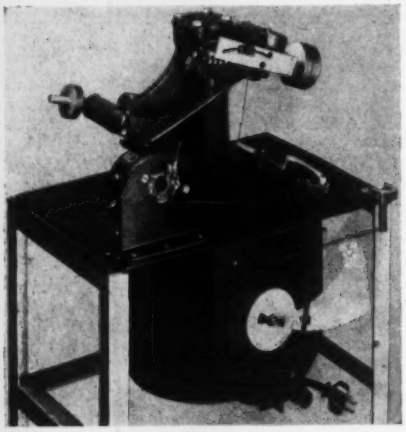


Fig. 2

operator an all's well picture, read at a glance. Conversely, it is said that when operating conditions are not right, meter immediately guides the operator to proper adjustments. A third pen, recording flue gas temperature or steam pressure, can be added to provide complete boiler performance information on the same 12" chart. New meter may be either wall-mounted or flush-mounted on a steel panel. Makers' meter bodies are available in a series of models to cover all ranges of differential and line pressures. Makers claim nine features and advantages for this new instrument: (1) direct-reading recorder; (2) continuous direct-reading watthour type steam flow integrator, having an easy-to-read cyclometer register; (3) adjustable zero-setting feature that obviates need for exact mercury content in steam meter body; (4) ratio adjustment to accommodate steam-flow-air-flow changes; (5) adjustable cam screws permitting adjustments of air flow readings at each chart point; (6) provisi for easy full-range field adjustments of a flow meter (½" to 5" of water); (7) co pletely sealed oil chamber provided by s gle-bell design; (8) exceptionally high o erating power provided by oversized bel (9) simplicity in design and easy unit re moval of complete mechanism, making fo trouble-free maintenance. Fig. 2 shows ho complete air flow measuring unit and re cording elements are assembled as one uni —*Republic Flow Meter Co., 2249 Diverse Parkway, Chicago, Ill.*

Internal-pivot Construction Electric Instruments

New line of small thin d-c. panel instru ments featuring internal-pivot construction is announced for use in aircraft, in radio and communications equipment, and for ap

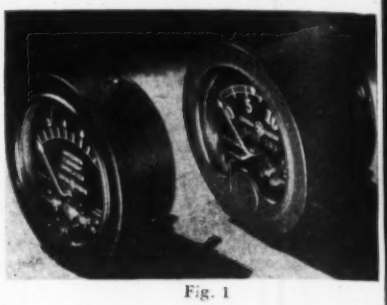


Fig. 1

plication to machines. Available with either brass or molded Textolite dust-proof and moisture-resisting cases in 2½" sizes, new line consists of d-c. voltmeters, ammeters, milliammeters, microammeters, r-f. ammeters and milliammeters, and d-c. volt-ammeters. (Volt-ammeter, one of those for naval aircraft, has a push-button to change reading from "amperes" to "volts.") In new instruments, pivots are solidly mounted on inside of armature shell instead of being secured to outside of armature winding in conventional manner. One jewel bearing is mounted rigidly on top of core-and-frame

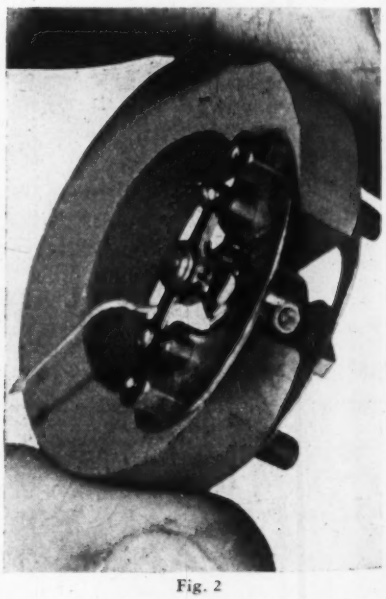


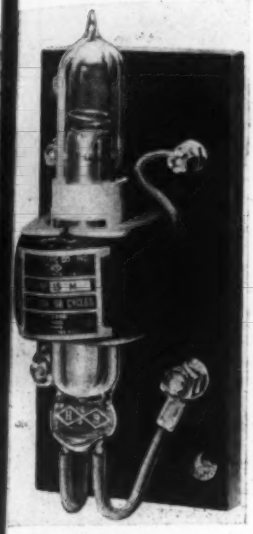
Fig. 2

assembly; the other in an adjustable sleeve fitted into lower part of soft-iron core. Thus, element assembly is a single self-contained unit, all parts of which are supported by a high-coercive cast magnet. It is said to be easily removable for field inspection or repair. See Fig. 2 in which it is shown approx. full-size. New design is said to enhance sturdiness of instruments and also to make them excellent for applications where vi-

...ration is present. In addition, combination ...f high torque and lightweight moving ele... ...ment results in a fast response, and good ...damping makes for ease and accuracy of ...reading. New instruments will operate satis...factorily in temperatures ranging from ...50°C. to 70°C. and are accurate to ±2% of ...full-scale value.—*General Electric Co., Schenectady, N. Y.*

Mercury Plunger Relay

New type normally-closed Mercury Plunger Relay is designed for emergency lighting, multiple street lighting and other applications where a normally-closed relay is required. It is particularly suitable for isolated locations because of: (1) only one moving part, (2) high-speed silent operation, (3) no exposed arc, and (4) maintenance-free. New unit is gravity operated; plunger is designed to displace enough mercury to flood contacts (which consist of two pools of mercury). When coil is energized, plunger is lifted, mercury recedes and the flooded pools of mercury separate into two pools, thus opening circuit. Mercury-to-mercury make and break is said to be ideally suited for high inrush and inductive circuits. Relays can be furnished with coils for any operating voltage and load ratings up to 4.5 kva. Units can be furnished with a variety of mountings and housings to meet individual requirements.—*H-B Electric Co., 6110 North 21st St., Philadelphia 38, Penna.*



Adjustable Diameter Gage

New "Model 236 B-123" is designed to check simultaneously the various diameters of a rotor shaft. It is adjustable to take any length of shaft up to 12" and can be furnished with gaging units to accommodate any diameter up to 4". The shaft is mounted between centers so that it can be rotated, permitting all its diameters to be checked easily. Gaging units and brackets

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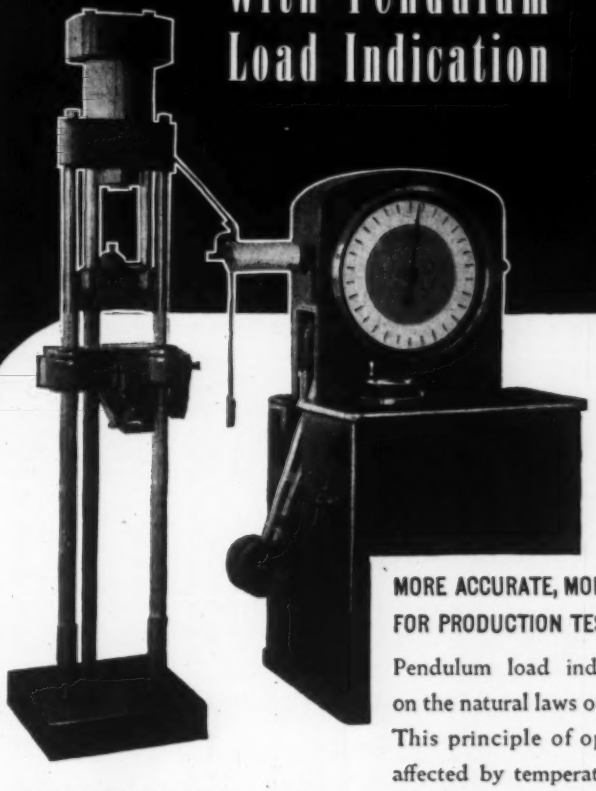

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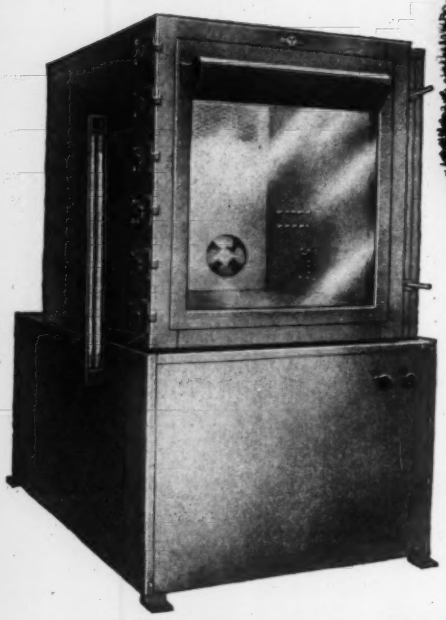

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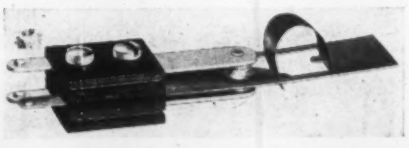
housing the centers are designed to slide in T slots in the base, can be moved longitudinally and locked in any position by a T bolt. Thus, diameters anywhere along length of shaft can be checked. Bearing surfaces of base are scraped; those of adjustable units are ground, to assure accurate adjustment for any position. Gaging units can readily be removed or additional ones added depending on the requirements of the part being checked. The part is held between centers under spring pressure. It is removed simply by pulling knob K. Next part is positioned on the fixed center (right-hand end), lowered into approximate position and left-hand center gently released. As center seeks center hole, part is automatically centered. Each diameter is checked independently of others. Each gaging unit consists of a dial indicator, a sensitive contact and a fixed contact; is mounted on stiff springs and is free to move transversely so that it can adjust itself to diameter of workpiece. Movement of sensitive contact is transferred directly to indicator point by a pantograph unit. This permits many positions to be checked, also provides a convenient means for adjusting the contacts to a master. The fixed contact also can be adjusted if necessary.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Open-blade Snap-action Switch

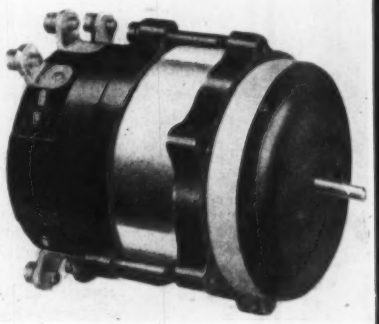
New small open-blade snap-action switch has been develcped to secure better contact pressure and greater speed of operation. It is designed for a wide variety of applications including machine tool control devices,



aircraft landing gear controls and for construction of various relays and contactors. A rolling spring, said to be unique, produces a positive snap action with less than 6 oz. operating pressure. Consequently, small coils may be used in relays incorporating the new development. This is also aimed to save both space and weight. Extremely fast action is said to minimize contact burning. Under tests of many millions of operations "no weakness has been shown." Switch is designed to permit both pre-travel and over-travel. It has a rating of 15 amps. at 125 volts a.c. Overall size is 3/16" × 11/16" × ½". Made in single-pole, single- and double-throw, set and return types. Also assembled to suit needs of relay builders.—*Acro Electric Co., 1324 Superior Ave., Cleveland, Ohio.*

Rotatable Transformer

New rotatable transformer, of lightweight precision construction for use in electronic devices, operates with either 32-volt 60-cycle or 110-volt 400-cycle a.c., transformer



may be continuously rotated at speeds up to 1800 r.p.m. With a 110-volt input, voltage varies from 0 to 193 volts according to position of rotor. Weighing 10 oz. and with an overall length of less than 3", unit may be incorporated into many types of units where compactness and light weight are a consideration. — *Electrical Development Dept., Kollsman Instrument Div., Square D Co., 80-08—45th Ave., Elmhurst, N. Y.*

Quick-reversing Hydraulic Valve

New solenoid-operated instantaneous-reversing hydraulic valve makes it possible to stop and reverse the motion of an aircraft gun turret in 1/20 second. Developed

at the request of a major airplane manufacturer, it was originally designed as a turret interrupter, but can be used in any case where it is desired to stop and reverse a movement before a predetermined danger point is reached. Unit operates electrically by means of a solenoid. Just before the desired "stop" position of the turret is reached, an electrical circuit is closed, energizing the solenoid which tips a cam in the valve unit. Action of cam closes normal openings of valve and opens operating openings, reversing flow of the hydraulic medium and consequently motion of turret. When turret has moved 2" in reverse direction, valve automatically returns to normal position and turret re-

sumes normal operation. Designing engineers strove for simplicity, light weight and easy servicing. Encased in an aluminum alloy body, the complete valve weighs 3.24 lbs. Each poppet and seat, contained in a cartridge, can be quickly removed and serviced, or replaced, without having to replace entire valve. Overall dimensions 2¾" × 2¾" × 6⅞". Solenoid operates on 24 volts d.c. and draws approx. 15 amperes.—*Adel Precision Products Corp., Burbank, Calif.*

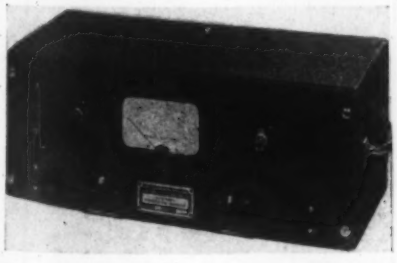
High-precision Wheatstone Bridge

New "No. 1622 High Precision Wheatstone Bridge" is a wide-range general-purpose instrument designed to combine high accuracy with convenience of manipulation.

Rheostat arm includes five decades of the following values: 9 × (1000 + 100 + 10 + 1, + 10 × 0.1 ohms. Switches are of extra-heavy construction. A positive detent mechanism assures correct positioning of brushes. Ratio resistors are plug controlled and include two coils of each of the following values: 10,000, 1000, 100, 10 and 1 ohms. When unity ratio is employed positions of ratio resistors involved may be conveniently reversed by changing location of two plugs, thus affording an exact test of the ratio value. Ratio values other than unity may be verified by substitution of the alternate resistors. All coils except the 0.1 ohm units are bifilar wound on large metal spools. The 0.1 ohm units are noninductive self-supporting coils of heavy manganin wire. Limit of error for all resistors above 0.1 ohm is 0.02%. Limit of error of 0.1 ohm resistors is 0.1%. Perforated metal case assures adequate ventilation and permits immersion of the resistors in oil should this be desired. A walnut cover is furnished. — *Rubicon Co., Ridge Ave. at 35th St., Philadelphia, Pa.*

Indicator for Use With Thermocouples

New "Electronic Temperature Indicator" is said to offer "many advantages to those industries where an expensive recording pyrometer is not required." A switch on



front panel allows instantaneous selection of three temperature ranges. Standard limits of instrument are—100°C. (148°F.) to 1000°C. (1832°F.) and normal accuracy is said to be ±2%. Five pairs of terminals for five thermocouples are provided, any

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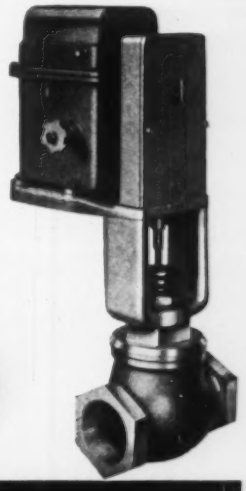

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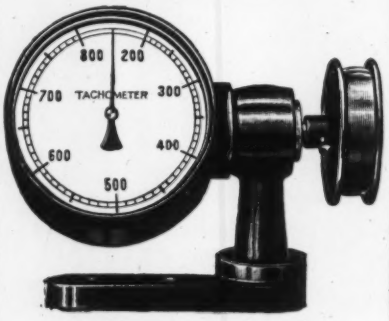

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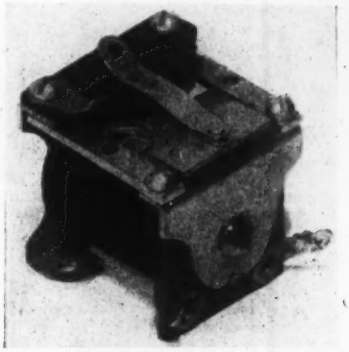
one of which can be switched into the circuit so that temperatures at five different points can be read. It is said that varying lengths of thermocouple leads do not affect calibration and that instrument can be operated with as much as 100 feet of connecting wire between thermocouple and indicator. No technical knowledge is required for operation of instrument which, being so designed that it cannot be damaged by overload or wrong application, is said to be particularly adapted for permanent use without supervision. Instrument case is a standard radio relay rack and panel built into a metal cabinet with black crackle finish. It weighs 24 lbs. and is constructed so that ordinary plant building vibrations will not affect accuracy.—*Industrial Electronics Div., North American Philips Co., Inc., 419 Fourth Ave., New York City.*

Light-weight Relay

New light-weight miniature relay weighs 38 grams (less than 1.4 ounce), measures approx. 1" on each side, is designed for operation at 0.2 watts. Photograph illustrates a normally-closed single-pole contact although a single-pole double-throw model can also be furnished. Resilient mounting of stationary contact eliminates contact bounce and results in desirable wiping action. There is no pivot or pin type bearing to introduce friction or to become sticky.



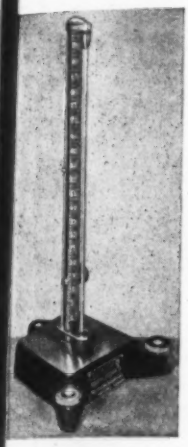
Instead, a twisted leaf spring is provided. Armature is mounted on this leaf spring and when relay coil is operated, pulling down armature, leaf spring twists and thus not only acts as a bearing but also provides necessary torque to bring armature back to normal position after relay coil is de-energized. Armature has symmetrical construction so that shock, acceleration and vibration have relatively little effect upon it. Contacts are rated at 1 ampere at 24 volts d.c., non-inductive.—*Control Corp., 600 Stinson Blvd., Minneapolis, Minn.*

Two-terminal Oil Capacitor

New "Type 10" oil capacitor is further improved by double-terminal feature. Heretofore this capacitor has had a single insulated terminal and grounded can (although when screw-mounted on a metal chassis it could be fully insulated by an insulating washer). Now, both terminal lugs are insulated from the "floating" can

and no insulating washer is required. Units are hermetically sealed, will pass all immersion tests required by Governmental agencies, are filled with either Hyvol vegetable oil or mineral oil, rated up to 4.0 mfd. at 600 volts d.c. and to 0.5 mfd. at 1500 volts d.c. The can, similar in design and dimensions to the usual inverted-screw-mounting metal-can electrolytics, is of aluminum or an approved substitute. New capacitors are available on high priorities only.—*Aerovox Corp., New Bedford, Mass.*

Tester for Determining Resiliency of Elastometers



Undersigned company announces that it has acquired sole manufacturing rights for "Bashore Resiliometer," formerly manufactured and sold by Testing Equipment Co., Manheim, Pa. (and not previously reported here because not previously reported to *Instruments*). This instrument measures resiliency of rubber and extensible plastic compounds by indicating the rebound of a weighted plunger dropped from a predetermined height. It has been found useful in the development of rubber and other elastomers for measuring rate and state of cure, factory control tests on uncured and cured samples, controlling quality of finished product without destroying product, comparing heat build-up of various compounds (the higher the resilience, the lower the heat build-up), for measuring plasticity of uncured compounds and masticated rubber (the higher the resilience, the lower the plasticity).—*Precision Scientific Co., 1750 North Springfield Ave., Chicago 47, Ill.*

Boxboard Tester

New boxboard tester will determine strength of boxboard from 0.014" liner to 0.140" solid kraft, as well as waterproof boxing material used for overseas shipments

which must withstand rough handling and extremes of moisture and temperature. It will also measure the strength, without deforming or flattening corrugations, of corrugated board from lightest nontest grade to heaviest grade of double-wall board, as well as thin plywood and vulcanized fibre. Tester has only one moving part, consists of a pendulum on the end of which is a rod bent to form an arc of 90°, with a 1" triangular metal point at the end. This point is shaped like the corner of a box

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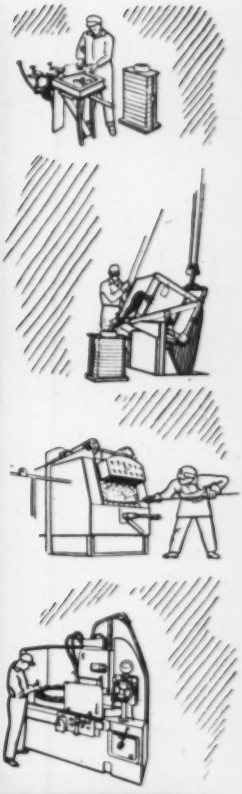

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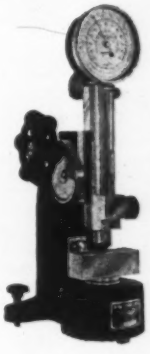

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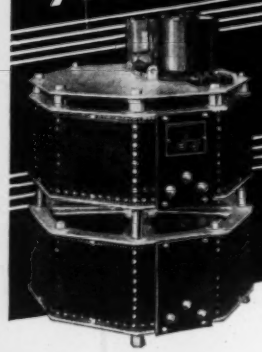

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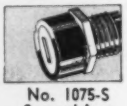

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in order to simulate actual shipping conditions, since majority of boxes damaged in transit are punctured by corners of other crates and boxes. Simulation of actual shipping conditions determined the 1" height of point. In operation, unit holds material to be tested firmly between two clamping plates which are level with axis of pendulum. Pendulum is operated by a trigger, and as this is tripped and released pendulum swings through its arc, number of degrees less than 180° through which it swings is a measure of energy dissipated in puncturing and bending material being tested. Tester's scale, which has an indicating hand, is calibrated so that reading is actual inch-ounces per inch of tear made during test.—*Special Products Div., General Electric Co., Schenectady, N. Y.*

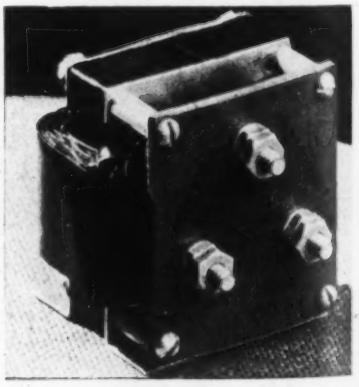
Contour Projector

New model of "Wilder Projector" contains a 2" diameter condenser replacing previous 1½" diameter condenser, thereby providing a larger beam of parallel light

and permitting use of larger diameter lenses in lower-power series. Optical efficiency of instrument has been increased. Diameter of new 10× lens is 1⅜" and that of new 20× lens 13/16". Larger condenser has also resulted in a new fully-enclosed head with better-ventilated lamp house. For smoothness of operation, spiral gears are now used in the focussing motion. Lenses are also set in larger and heavier mounts. Wilder Projectors are now available in magnifications of 10× to 100×.—*George Scherr Co., 128 Lafayette St., New York 13, N. Y.*

Two-phase to Three-phase Transformers for Aircraft

New two-phase to three-phase transformer for use with aircraft gyro instruments provides correct power supply for the operation of G-E Types KB-1 (gyro-horizon)

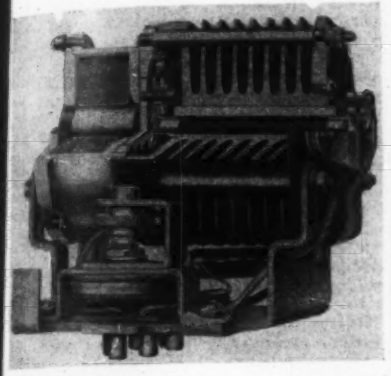


and KC-1 (directional gyro), three-phase instruments equipped with the 750-va Holtzer-Cabot inverter. It will operate one or two instruments, bringing them up to full speed in approx. 1¼ minutes at normal temperature (25°C.). A 115-volt three-

hase, 400-cycle output is supplied from the ual 26-volt and 115-volt output provided by the inverter. Transformer measures pprox. 2⅝" × 2½" × 2¾", weighs 13.6 unces, operates efficiently at any altitude hen suitable ventilation is provided, meets SAAF requirements.—*General Electric Co., Schenectady, N. Y.*

Aircraft Voltage Regulator

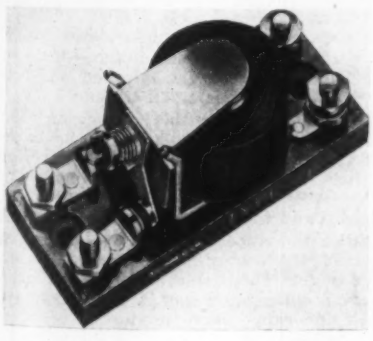
New "Type 1042" Carbon Pile Voltage Regulator is designed to control the voltage of 24-volt aircraft systems which use engine-driven generators rated from 1.5 to 6



kw. It comprises a stack of carbon disks held in a supporting housing which incorporates fins to dissipate heat. Regulation is accomplished by varying pressure on disks by a series of radially arranged leaf springs controlled by an electromagnet. Electromagnet being actuated by the generated voltage, a constant generated voltage is said to be maintained without lag or fluctuation. Magnet has a main shunt winding and an additional load-compensating winding for use when generator is operated in parallel with other generators. Regulator is so constructed that it is impervious to air-borne foreign matter which might be present under condition of blast cooling. Regulator can be used in conjunction with any 30-volt generator that requires a resistance range of 0.7 to 55 ohms and wherein maximum regulator wattage will not exceed 75 watts continuously. For installation where voltage regulator can be blast-cooled, unit may be operated continuously at 100 watts. Since carbon disks are under continuous pressure, it is said, voltage regulation is not affected by normal conditions of vibration. Elimination of voltage regulator contacts is said to assure a precision means of control with no contacts to burn, stick, pit or get out of adjustment. Generator weighs 2.6 lbs. Overall dimensions are: 4⁹⁄₁₆" long, 4¹⁄₁₆" wide, 3⅞" high.—*Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.*

25-ampere Aircraft Contactor

New 25-amp. "Type B2A" (Class 9350) aircraft contactor is manufactured to meet Army Air Forces specification No. 94-32185D, may be used for remote control, starting and stopping of d-c. motors, or as relays in gun fire, lightning or communica-



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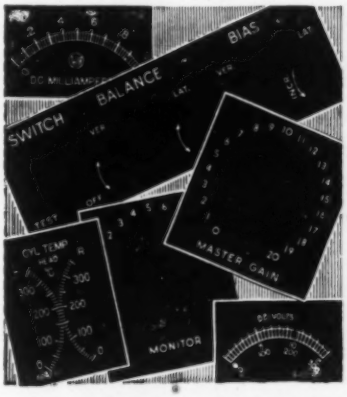

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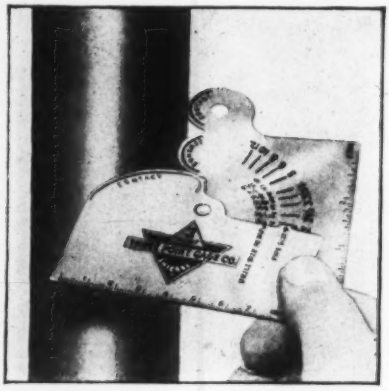
tion circuits. It is said that simplicity of design and heavy-duty contact capacity assure dependable performance under severe flight conditions. New contactors weigh 7 oz. and are rated 25 amperes continuous duty for potentials up to 29 volts d.c. They will operate successfully under acceleration forces up to 10*G* or vibration conditions as severe as 55 c.p.s. at 1/16″ excursion. They are suitable for operation through a temperature range of −65°F. to +160°F. and are not damaged when exposed to temperatures of −75°F. to +200°F.—*Square D Co., 4041 N. Richards St., Milwaukee 12, Wis.*

Pipe Gage

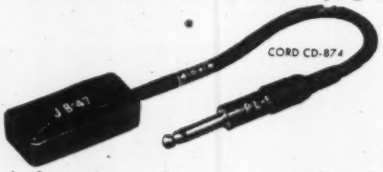
New pocket size "Three-Point Pipe Gage" for instantaneous measurement of all sizes of pipe from ⅛″ to 12″, consists of two pivoted steel plates with edges curved at



three points for contact with the pipe to be measured, together with scale which indicates not only the pipe size in terms of inside diameter but the drill size for tapping. Gage measures by the geometrical method of determining the outside arc of the pipe at three points of contact. An additional advantage claimed for this new gage is that it is necessary to contact only a small section of the pipe contour and that it will measure pipe in any position, even against the wall or in a corner, and will measure a covered pipe if there is a small opening near a union or other fitting where the gage may be slipped in. It is also pointed out that the gage can be applied in dark places and taken to the light for reading. The gage is constructed of steel with deep etched numerals, and the size when closed is only 2½″ × 4¼″.—*Three-Point Gage Co., 3821 Broadway, Chicago, Ill.*

Junction Box Set

New "CD-874 Cord Set with Junction Box JB-47 assembly" consists of a length of CD-874 special two-conductor tinsel cordage with a PL-55 two-conductor plug at-



tached to the cordage on one end, and a JB-47 junction box attached on the other end. The JB-47 junction box has a two-piece Bakelite case. Lower section of case has two silver-plated copper terminal jumpers and four terminal binding posts. Rigid cord clamps molded into both sections of case hold cordage in place and prevent slipping. A tight-fitting Neoprene jacket sleeve makes a close seal over the end of the PL-55 plug which is connected to the cordage. The Complete cord set, or any integral part, can be furnished promptly. Product is guaranteed to withstand all U. S. Army Signal Corps tests and to meet their specifications.—*Trav-Ler Karenola Radio & Television Corp., 1030-9 W. Van Buren St., Chicago 7, Ill.*

Instruments' Book Shelf

Gmelins Handbuch der anorganischen Chemie (Gmelin's Handbook of Inorganic Chemistry) 8th Edition. Herausgegeben von der Deutschen Chemischen Geselschaft. Verlag Chemie G.m.b.H., Berlin, 1939.

System-Number 59, Teil FI, Lieferung 1. Iron,—Sampling, Gases, Residue Analysis. Paper, 7 × 10¼ inches, 164 pages. Price 19.50 R.M.

General discussion of sampling of iron and steel, drawn from the literature, including liquid and solid iron and steel, ferroalloys, etc.; of the detection and analysis of iron and steel for gases, with particular reference to oxygen, including a comprehensive discussion of fusion methods and of residue methods (the iodine method, the bromine method, the electrolytic method, acid methods, etc.); and of nitrogen and hydrogen. The treatment is detailed and exhaustive. There are seven photographs and numerous drawings.

Teil A, Lieferung 9. Iron,—The Binary Systems from Fe-Mg to Fe-Pr. Paper, 7 × 10¼ inches, 128 pages. Price 43.50 R.M.

Literature summary of binary and ternary systems from Fe-Mg to Fe-Pr, alphabetically. Apparently carefully compiled and complete. Numerous diagrams.

Teil A, Abteilung I (Lieferung 1-5), Abteilung II (Lieferung 6-9) Iron: Titles, Abbreviations, Contents, Index. Paper, 7 × 10¼ inches, 111 pages. Price not stated.

List of abbreviations. Table of contents for Teil A. Index for the several sections of Teil A.

—ROBERT F. MEHL, *Head of Metallurgical Dep't, Carnegie Institute of Technology, Pittsburgh.*

The Physical Examination of Metals—Volume II. By BRUCE CHALMERS and A. G. QUARRELL. Longmans, Green & Co., New York, 1942. Cloth, 5½ × 8½ inches, viii + 280 pages. Price $6.00.

In this volume the authors describe the application of electrical methods to the examination of metals (In Vol. 1, Chalmers covered optical methods). In presenting the various techniques, which may be broadly classified as electrical, the authors have attempted to indicate the scope and limitations of each of the methods described. The book is divided into the following chapters: Magnetism; Electrical Measurements; X-Ray diffraction; Diffraction of Electrons; Electron Microscope; and Radiography.

—RICHARD RIMBACH

The Condensed Chemical Dictionary. Third Edition. Compiled by Chemical Engineering Catalog, THOMAS C. GREGORY, Editor. Reinhold Publisaing Corp., New York, 1942. Cloth, 6 × 9¼ inches, 756 pages. Price $12.00.

The first edition of this extremely useful reference volume appeared in 1919 and was prepared by Francis M. Turner. The need for such a useful book has increased with time. This is the third edition which was completely revised and enlarged under the supervision of Thomas C. Gregory.

It would be impossible to go over such a reference volume page by page, as is possible in reviewing a text book. The reviewer has used the previous editions continually since the first edition and has always found the data accurate and useful.

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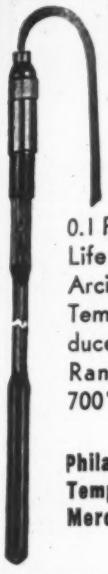

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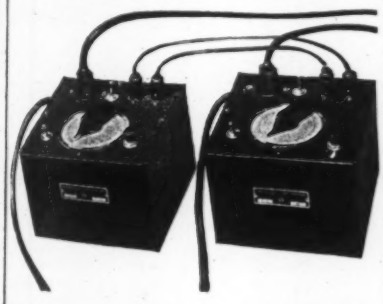

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—RICHARD RIMBACH

Waugh Laboratories. WAUGH LABORATORIES, 420 Lexington Ave., New York, 1942. Binder, 9 × 11¼ inches, containing eight sections. Free (but limited distribution).

Our policy is to describe in the "Manufacturers' New Literature" Department the commercial publications issued by laboratories as well as by manufacturers. Exceptions have seldom been made because it is difficult to lay down a sharp line dividing the purely "commercial" from the purely "educational."

Technically, this publication is a "prospectus." Physically, it is a book—such a sumptuous book that the girls who open and distribute the mail in this office instinctively or intuitively recorded it as a "book received, reviewer to be appointed" and put it on the editor's desk. Their instinct or intuition thus found an immediate answer to what might have been a knotty question of policy.

Perhaps the best brief description of the contents of this book is its full title: "Waugh Laboratories—Its Services, Instruments and Facilities for Testing Structures, Equipment and Materials. Also a pictorial presentation of the types of Structures, Equipment and Materials most frequently requiring tests for Stresses, Strains, Vibrations, Acceleration or Sound."

Following a few introductory pages, there is a 32-page pictorial section containing hundreds of photographs arranged by fields of research as follows: Aviation Industry, Bridge Engineering, Combat Matériel, Reinforced Concrete, Marine Engineering, Oil Industry, Railroad, Steel Structures. Throughout this section (and elsewhere throughout the book) there are colored index signals and numbers which vividly and unmistakably refer the reader to the classes and types of instruments used in the pictured applications—the colors matching the colored tabs on the initial pages of the seven subsequent sections wherein instruments are described.

These instrument sections are as follows: Induced Vibrations and Forces; Vibration and Noise Measuring; Strain Measuring; Auxiliary Tools for Vibration Analysis; Loads, Forces and Shocks; Time, Space and Movement Recording; Heavy Testing.

Most of the instruments are well-known items of well-known makes; some are of special design. Their descriptions are educational rather than commercial, so that this book as a whole is radically different from a commercial catalog. The reader is almost startled when he comes across a brief unobstrusive statement that he may rent the instruments for specific tests or even purchase them outright.

Although this book is free and although its purpose is to expand the business of the Waugh Laboratories, it certainly deserves a better fate than that usually suffered by "a piece of advertising literature." It undoubtedly will earn for itself a prominent place on the bookshelf (and in the memory) of many an industrialist.

—M. F. BEHAR

Progress in the Art of Metering Electric Energy. COMMITTEE ON INSTRUMENTS AND MEASUREMENTS, American Institute of Electrical Engineers, New York, 1941. Paper, 8½ × 11 inches, 36 pages. Price 25 cents to members, 50 cents to nonmembers.

This carefully prepared history of the metering art contains four parts: I.—Origins, covering invention and pioneering development before 1900, with particular at-

Continued on page 658

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In this department we report ALL pieces of new literature pertaining to Instrumentation received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

K-293 **Use of Gage Blocks.** Folder, 8½" × 11", 4 pages, illustrates and describes numerous uses of these standards of measurements as they are employed daily in both the inspection departments and in the machine shops. George Scherr Co., Inc., 128 Lafayette St., New York, N. Y.

K-294 **Precision Snap Switches.** Catalog 60, loose leaf folder, 8½" × 11", 38 pages gives dimensions, characteristics, prices covering the following: Bakelite Microswitch; Metal-Clad Microswitch; Micro Limit Switch; Explosion Proof Microswitch; Splash Proof Microswitch; Microswitches for Aircraft. Micro Switch Corp., Freeport, Ill.

K-295 **Jewel Light Assemblies.** Form 5, 8½" × 11", 6 pages illustrates many dial and jewel pilot light assemblies. Drake Mfg. Co., 1713 W. Hubbard St., Chicago, Ill.

K-296 **Small (1/1500 H.P.) Motor.** Bulletin 1024, 8½" × 11", 4 pages describes the new Type K frame motor. Bodine Electric Co., 2254 W. Ohio St., Chicago, Ill.

K-297 **Reducing Light Reflection of Optical Surfaces.** Bulletin, 8½" × 11", 10 pages, gives information concerning the Opticote and Reflecticote surface. The history of the process and the effects on exposure, picture quality and optics are included. Vard Mechanical Laboratory, 2980 E. Colorado St., Pasadena, Calif.

K-298 **Valve Operators.** Catalog A8, 8½" × 11", 4 pages describes a mechanism designed for industrial operation of valves, dampers, or other control devices between two adjustable positions for regulation of temperature, pressure, flow, or level. The literature covers essential engineering information, design features, and operating data. Valves, commonly mounted to this unit, are illustrated; and, tabular data are given to dimensions and operating force. Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia 44, Pa.

K-299 **Laboratory Utilities.** Catalog 600, 8½" × 11", 112 pages containing detailed information on an extensive variety of laboratory apparatus and equipment, many new "wrinkles" in familiar items, dozens of practical ideas for stepping up laboratory efficiency. Precision Scientific Co., 1750 N. Springfield Ave., Chicago, Ill.

K-300 **How to Keep Flowmeters Accurate.** Reprint 28, 8½" × 11", 8 pages is a guide to accurate metering, written by W. C. Bennett. The author has achieved an intensely practical presentation. With no waste words he tells how to prevent and cure meter ills to the end that the flow charts of America's central stations, institutions and industrial plants may do a 100% job. Cochrane Corp., 17th and Allegheny Ave., Philadelphia, Pa.

K-301 **General Radio Experimenter.** The August issue of this publication has the following articles: Effect of Humidity on Electrical Measurements; Checking the Accuracy of Aircraft Tachometers; Torsional Vibration Analysis. General Radio Co., 30 State St., Cambridge, 39, Mass.

K-302 **Capacitors.** Form 586, 8½" × 11", 2 pages illustrates two types of capacitors: the bushing mounted capacitors and the silver mica capacitors. Centralab Div., Globe-Union, Inc., Milwaukee, 1, Wis.

K-303 **Control Equipment for Foundry Sand Reclamation.** The September issue of Wheelco Comments is devoted to sand reclamation control at Wright Aeronautical. Wheelco Instruments Co., Harrison and Peoria Sts., Chicago, 7, Ill.

K-304 **Electrical Connectors.** Visual wall charts which will be of immense value to all branches of the Army, Navy and industry using standard Army, Navy Specifications, electrical connectors are described in a 4-page folder. Cannon Electric Development Co., 3209 Humboldt St., 31, Los Angeles, Calif.

K-305 **Solving Industrial Crimes.** Case No. 29 describes the use of a graphic wattmeter for studying power problems of a New Jersey plant and which disclosed a 50% labor loss.. Esterline-Angus Co., Inc., Indianapolis, Ind

K-306 **Permanent Magnets.** Manual No. 2, 8½" × 11", 30 pages, has a large number of views showing the engineering and production facilities of Indiana Steel Products. Other sections of the Manual are devoted to Fundamental Considerations of Permanent Magnet Applications; Permanent Magnet Materials and Their Comparative Values; Physical Characteristics of Alnico; Factors of Design, Magnetizing, Testing and Aging. Indiana Steel Products Co., Valparaiso, Ind.

K-307 **Sound Advances.** The publication published by the Sound Apparatus Company in July is devoted to the development of automatic graphic recorders. The first issue fully describes the Model PS automatic high speed power level recorder. Sound Apparatus Co., 150 W. 46 St., New York, 19, N. Y.

K-308 **Micro Projector.** Folder, 8½" × 11", 6 pages contains complete operating instructions for the projector. Various methods in preparing charts for the checking of angles, radii, tapers, etc., are covered. George Scherr Co., 128 Lafayette St., New York, 13, N. Y.

K-309 **Surface Plates.** Leaflet, 3½" × 8½", 6 pages describes a new development—a granite surface plate. It is claimed that an extra hard precision surface lasting many years under normal conditions is assured. Herman Stone Co., 324 Harries Bldg., Dayton, 2, Ohio.

K-310 **Plug and Ring Gages.** Leaflet, 8½" × 11", 4 pages catalogues sizes and prices. Acme Industrial Co., 200 N. Laflin St., Chicago, Ill.

K-312 **Dial Indicator.** Folder, 8½" × 11", 4 pages, describes the Testmaster, a miniature gage adaptable to all tool posts, height and surface gages, etc. Federal Products Corp., 1144 Eddy St., Providence, R. I.

K-313 **Boiler Meter.** Bulletin 420, 8½" × 11", 8 pages, describes the new Republic meter which indicates, records and integrates steam flow from the boiler and records rate of air flow for combustion. Republic Flow Meters Co., 2240 Diversey Pkwy., Chicago, 47, Ill.

K-314 **Automatic Control and Recording Instruments.** Bulletin 1880, 8½" × 11", 4 pages, is a condensed index of products and services of the Bristol Co., Waterbury, Conn.

K-315 **Boiler Water Control.** Bulletin L-50, 8½" × 11", 1 page, explains the No. 247 boiler water feeder and shows the application of the No. 29 safety relief valve. McDonnell & Miller, Wrigley Bldg., Chicago, Ill.

K-316 **Relief Valves.** Reprint 26, 8½" × 11", 4 pages, shows new sizing data on relief valves used for protecting low-pressure equipment. Cochrane Corp., 17th and Allegheny Ave., Philadelphia, 32, Pa.

K-317 **Tensile Tester.** Bulletin, 8½" × 11", 4 pages, describes the veneer and thin plywood tester and its use. Some of the points it brings out con-

erning the testing procedure are that t specimens require no special prepaation, a test can be made in a matter f seconds, and variable human judgents can be reliably checked or verid by direct readings on the device with gle or no trouble. Streeter-Amet Co., 01 Ravenswood Ave., Chicago, Ill.

K-318 **Ohmite News.** The Aug.-Sept. ssue has an article entitled "Exploring New Worlds with the Electron Microscope." Ohmite Mfg. Co., 4835 Flournoy St., Chicago, Ill.

K-319 **Plugs and Jacks.** Catalogue 830, 8½" × 11", 4 pages, catalogues U. S. Army and Navy Specification plugs and jacks. Universal Microphone Co., Ltd., Inglewood, Calif.

K-320 **Photoelectric Smoke Meter.** Bulletin, 8½" × 11", 5 pages, describes a new smoke meter which can be used on Diesel engines as well as furnaces. Photovolt Corp., 95 Madison Ave., New York, N. Y.

K-321 **Photoelectric Recorder.** Bulletin GEA-2394A, 8" × 10½", 8 pages, describes a high speed photoelectric recorder for temperature surveys, development testing, high speed recording, pressure measurement, physiological research, equipment tests. General Electric Co., Schenectady, N. Y.

K-322 **pH Indicator.** Catalog E-963, describes a new and improved portable universal pH indicator which, direct reading with glass, hydrogen and quinhydrone electrodes, with the following advantages: (1) self-contained electrodes of new and improved design; (2) in addition to the standard 50 ml sample beaker, a small volume holder for samples of approximately 2 ml; (3) a reduction in the number of knobs and switches used in standardizing and measuring; (4) a polarity reversing switch for the volt range. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, 44, Pa.

K-323 **Electronic Tubes.** Loose Leaf, 8½" × 11", 12 pages, contains technical data pertaining to the various electronic power and transmitting tubes now manufactured by this organization for Army, Navy and Air Corps application. Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark, N. J.

K-324 **Relays.** Folder, 8½" × 11", 4 pages, illustrates a number of mercury plunger relays. List prices are shown for relays using standard coils for 110 volts 60 cycles, 220 volts 60 cycles, and 115 volts d.c. H-B Electric Co., 6122 N. 21 St., Philadelphia 38, Pa.

K-325 **General Radio Experimenter.** The September issue has an article entitled "Identification of Harmonics in a Harmonic Series." General Radio Co., 30 State St., Cambridge 39, Pa.

K-326 **Magmotor Memo.** The Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill., have started the publication of this new periodical for communication, radio and electronic engineers.

K-327 **Dynamotors.** Catalog 100, 8½" × 11", 10 pages, catalogues a number of dynamotors for aircraft, marine, police and all mobile radio equipment. Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

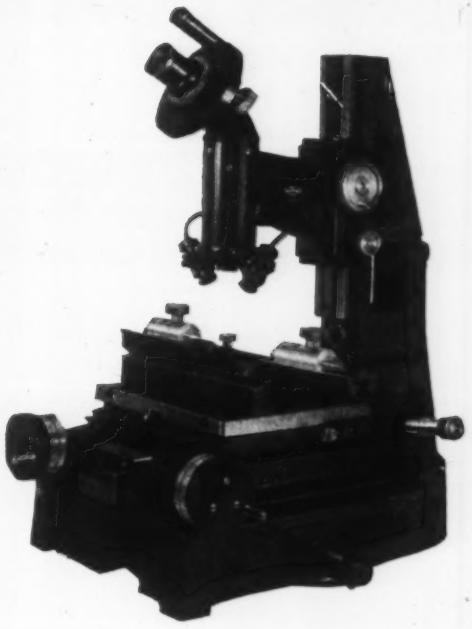
K-328 **Automatic Control.** Bulletin DM006, 18" × 24", 2 sides, illustrates automatic control and recording instruments as well as several recent applications. Bristol Co., Waterbury, Conn.

K-329 **"Holocator."** Form 108, 8½" × 11", 4 pages, illustrates a toolmakers' device for precision drilling, reaming and layout of dies and drill jigs. Dayton Rogers Mfg. Co., Minneapolis, Minn.

K-330 **Spectrometer.** Sheet, 8½" × 11", 1 page, describes a precision spectrometer designed for prism and refraction angle measurements and for general spectroscopic determinations having an accuracy of 10 seconds. O. C. Rudolph, 55 Van Dam St., New York, N. Y.

K-331 **Motor Driven Controls.** Bulletin 71, 8½" × 11", 4 pages, illustrates a number of applications of these controls Reynolds Electric Co., 2650 W. Congress St., Chicago, Ill.

K-332 **RMA Resistor-Condenser Color Code Wall Chart.** Chart, 8½" × 11" presents in both pictorial and convenient tabular form the complete RMA resistor and condenser color codes and also the different color code marking arrangements used by all resistor and molded mica condenser manufacturers. Radio & Technical Publishing Co., 45 Astor Place, New York, N. Y.



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